UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

Note to Reader

Background: As part of its effort to involve the public in the implementation of the Food Quality Protection Act of 1996 (FQPA), which is designed to ensure that the United States continues to have the safest and most abundant food supply. EPA is undertaking an effort to open public dockets on the organophosphate pesticides. These dockets will make available to all interested parties documents that were developed as part of the U.S. Environmental Protection Agency's process for making reregistration eligibility decisions and tolerance reassessments consistent with FQPA. The dockets include preliminary health assessments and, where available, ecological risk assessments conducted by EPA, rebuttals or corrections to the risk assessments submitted by chemical registrants, and the Agency's response to the registrants' submissions.

The analyses contained in this docket are preliminary in nature and represent the information available to EPA at the time they were prepared. Additional information may have been submitted to EPA which has not yet been incorporated into these analyses, and registrants or others may be developing relevant information. It's common and appropriate that new information and analyses will be used to revise and refine the evaluations contained in these dockets to make them more comprehensive and realistic. The Agency cautions against premature conclusions based on these preliminary assessments and against any use of information contained in these documents out of their full context. Throughout this process, If unacceptable risks are identified, EPA will act to reduce or eliminate the risks.

There is a 60 day comment period in which the public and all interested parties are invited to submit comments on the information in this docket. Comments should directly relate to this organophosphate and to the information and issues available in the information docket. Once the comment period closes, EPA will review all comments and revise the risk assessments, as necessary.

These preliminary risk assessments represent an early stage in the process by which EPA is evaluating the regulatory requirements applicable to existing pesticides. Through this opportunity for notice and comment, the Agency hopes to advance the openness and scientific soundness underpinning its decisions. This process is designed to assure that America continues to enjoy the safest and most abundant food supply. Through implementation of EPA's tolerance reassessment program under the Food Quality Protection Act, the food supply will become even safer. Leading health experts recommend that all people eat a wide variety of foods, including at least five servings of fruits and vegetables a day.

Note: This sheet is provided to help the reader understand how refined and developed the pesticide file is as of the date prepared, what if any changes have occurred recently, and what new information, if any, is expected to be included in the analysis before decisions are made. **It is not meant to be a summary of all current information regarding the chemical.** Rather, the sheet provides some context to better understand the substantive material in the docket (RED chapters, registrant rebuttals, Agency responses to rebuttals, etc.) for this pesticide.

Further, in some cases, differences may be noted between the RED chapters and the Agency's comprehensive reports on the hazard identification information and safety factors for all organophosphates. In these cases, information in the comprehensive reports is the most current and will, barring the submission of more data that the Agency finds useful, be used in the risk assessments.

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EFED RED CHAPTER FOR DICROTOPHOS

Table of Contents

1. Use Characterization

Dicrotophos (Active Ingredient No. 35201) is an organophosphate insecticide and aracnicide. It is registered for use on cotton (unspecified) and ornamental and/or shade trees. It is applied to cotton as liquid spray on foliage, with a maximum label application rate of 0.5 lb ai/A per application. Up to three applications may be made to cotton within a growing season. It may be applied to cotton with ground or aerial equipment, but not through an irrigation system. Dicrotophos is registered for use on ornamental and shade trees only as a tree-injection application. Micro-injection units, placed around the base of tree trunk, inject dicrotophos into the xylem of the tree, providing systemic protection from leaf-eating and boaring insects and mites. One capsule is used for each 2 inches of tree diameter at breast height.

Cotton is grown in the southern U.S. from Califonia to North Carolina. The biggest cotton growing areas are in central California, the Mississippi Valley, southern Arizona, Texas, and southern Georgia (Fig. 1). Although 1987 Resources for the Future data indicates that the distribution of dicrotophos use closely follows the distribution of cotton (Fig. 2), the registrant recently indicated in a 17 September 1998 meeting that dicrotophos is being used primarily in the Mississippi Valley region. The Biological and Economical Analysis Division estimates that 1,145,000 acres of the 12,689,000 acres (9%) of cotton are treated with dicrotophos. The states with the highest usage are Texas, Mississippi, Arkansas, Louisianna, and Tennessee, which together account for 85% of the use of dicrotophos. Approximately 313,000 pounds are applied per year. The typical use rate is 0.3 lb ai/A. Only a very small amount of dicrotophos is used in tree-injection treatments (<1000 lb annually).

2. Exposure Characterization

a. Chemical Profile

Molecular Weight	237.19
Empirical Formula	$C_8H_{16}NPO_5$
Solubility	1.00×10^{6} ppm
Vapor Pressure	4.7×10^{-6} mm Hg
Henry's Constant	3.13×10^{-11} Atm M^3/Mol (Calculated)
K_{oc}	11 - 187 ml/g

b. Environmental Fate Assessment

Dicrotophos (1, 3-hydroxy-N,N-dimethyl-cis-crotonamide, dimethyl phosphate) is a contact, systemic organophosphate used on cotton, ornamental and/or shade trees. The major routes of dissipation for dicrotophos in the environment are microbial-mediated degradation in soil and movement into surface and shallow ground waters. Laboratory studies showed that abiotic hydrolysis rates were pH-dependent (alkaline-catalyzed), and followed first-order kinetics. The registrant-calculated half-lives for dicrotophos in sterile aqueous solutions at pH 5, 7, and 9

were 117, 72, and 28 days, respectively. The half-life values at pH 5 and 7 were extrapolated values. Two major degradates were identified in all the hydrolysis test solutions: SD 6167 (N,N-dimethylacetoacetamide, an ester cleavage product of dicrotophos) and SD 228001(O-desmethylated dicrotophos). Aerobic and anaerobic aquatic metabolism studies were not submitted for this chemical.

Laboratory studies also showed that dicrotophos was stable to photolysis in aqueous solutions (pH 7) and on soil surfaces (sandy loam soil - pH 5.7). The registrant calculated half-life for the aqueous photolysis study was 48 days at pH 7. The hydrolytic degradates SD 6167 and SD 228001 were isolated from the irradiated and dark control solutions. In the soil surface photolysis study, 80% of the applied parent was recovered in both the light and dark controls after 30 days of exposure.

Laboratory soil metabolism studies showed that dicrotophos degraded rapidly under aerobic and anaerobic conditions. Under aerobic conditions, the soil half-life of dicrotophos was 2.7 days in a Hanford sandy loam soil (pH 5.7). The major soil metabolite was SD 6167, which was present at 20% of applied after 5 days incubation and then declined to 1.0% after 14 days. CO_2 accounted for about 58% of the applied after 14 days posttreatment, while unextracted residues accounted for 26.5% of the applied radioactivity. Under anaerobic conditions, dicrotophos degraded with a half-life of 7 days week in a Hanford sandy loam soil. The major degradates were N,N-dimethylacetoacetamide (SD 6167) and the hydroxy derivative of N,N-dimethylacetoacetamide, which accounted for 48% and 13% of the applied after 33 days postflooding. CO_2 totaled 18% of the applied, while unextracted soil residues were 6.2%.

Adsorption/desorption studies showed that dicrotophos was mobile in sand, sandy loam, silt loam and clay soils with Freundlich K_{ads} values of 0.07-3.58 ml/g. Respective K_{oc} values were 11, 53, 40 and 187. The major degradate SD 6167 was highly mobile in both sand and sandy loam soils. Supplemental soil TLC studies showed that aged dicrotophos was highly mobile in sandy soil and of intermediate mobility in sandy loam soil. The major metabolite SD 6167 was highly mobile in both soils. In supplemental terrestrial field studies in Mississippi and Georgia, dicrotophos dissipated with a half-life of 2.2 days. The formation and decline of degradates were not addressed in these field studies. Fish accumulation studies were done under static conditions with monocrotophos instead of dicrotophos. This study showed that monocrotophos residues did not accumulate in rainbow trout.

The registrant reported the vapor pressure of dicrotophos as 9.3 mPa at 20C, which is equivalent to 7.0×10^{-5} mm Hg at 20°C. A laboratory volatility study on soil, using the technical ingredient, showed that only 0.1% of applied dicrotophos volatilized after 7 days.

2. Environmental Fate and Transport Data

I. Degradation

a. Abiotic Hydrolysis (161-1)

(3-^{14}C) Dicrotophos, at 50 ppm, degraded with registrant-calculated half-lives of 28, 72, and 117 days in sterile aqueous buffered solutions adjusted to pH 9, 7, and 5, respectively. The registrant-calculated half-lives at pH's 7 and 5 were extrapolated values. The test solutions were

incubated in the dark for 28 days at 25°C.

The degradates SD 6167 (N,N-dimethylacetoacetamide, an ester cleavage product) and SD 228001 (O-desmethylated dicrotophos) were identified in all test solutions. After 28 days of incubation, SD 6167 reached a maximum of 31.2% at pH 9, 4.8% at pH 7, and 1.5% at pH 5. The rate of formation of SD 6167 is pH-dependent and alkaline-catalyzed. The other major degradate, SD 228001, reached a maximum of 16.5% after 28 days of incubation at pH 9, 18.8% at pH 7, and 13.6% at pH 5. The rate of formation of SD 228001 was not pH-dependent. Uncharacterized degradates ranged from 0.6 to 2.9% in all the test solutions, and material balances ranged from 95.8% to 100.7%.

The hydrolysis (161-1) data requirement is fulfilled (MRID 00160823).

b. Photolysis in Water (161-2)

Radiolabeled dicrotophos (50 ppm) was stable to photolysis in sterile aqueous pH 7 buffer solutions that were irradiated with artificial light at 25-29°C for 28 days (12 hours irradiation/day). The light source was an "Opti-Beam 1000 laboratory solar simulator", which had a spectrum similar to sunlight, but was otherwise uncharacterized. Dicrotophos decreased from 97.7-98.4% of the applied to 61.7-66.9% in the irradiated solutions and to 63.7-68.8% in the dark controls between 0 and 28 days posttreatment. The registrant-calculated extrapolated half-lives were 48 days in the irradiated solutions and 51 days in the dark controls. The hydrolytic degradates SD 6167 and SD 228001 were identified in similar concentrations in both the irradiated and dark control solutions. SD 6167 averaged 3.5-7.9% of the applied throughout the experiment, while SD 228001 increased from an average of 7.75% at 7 days posttreatment to 25.4% at 28 days.

After this study was reviewed, the registrant provided additional information which characterizes the light source. The photolysis in water (161-2) data requirement is fulfilled (MRID 00160824).

c. Photodegradation on Soil (161-3)

Radiolabeled dicrotophos, at 25 ppm, decreased from 100.3% to 80.6% of the applied on the irradiated samples and from 100.3% to 79.6% on the dark controls after 30 days of incubation on sterilized Hanford sandy loam soil (pH 5.7) at 27-35°C. The light source was a bank of GE F40BL and BLB lamps, which had a spectrum similar to sunlight at wavelengths >400 nm. No degradates were detected at >1.0% of the applied. Unextracted residues increased to 17.3-20.1% of the applied at 21 and 30 days; additional extraction of the 30-day irradiated soil identified approximately 90% of these residues as dicrotophos.

After this study was reviewed, the registrant provided additional information which characterizes the light source. The photodegradation in soil (161-3) data requirement is fulfilled (MRID 00160825).

d. Photodegradation in Air (161-4)

The photodegradation in air (161-4) data requirement is not required because dicrotophos is stable to photolysis.

e. Aerobic Soil Metabolism (162-1)

The registrant submitted two aerobic soil metabolism studies. The first study (MRID 00115295) showed that dicrotophos (0.2 mg/kg) degraded with registrant-calculated half-lives of 30 hours in sandy soil (pH 7.2) and 72 hours in sandy loam soil (pH 5.0 - 5.5) incubated in the dark at 22°C for 14 days. This study was not accepted because the analytical methodolgy and material balances were incomplete and major degradates were not identified.

In a second soil metabolism study (MRID 00160826), radiolabeled dicrotophos, at 10 ppm, degraded with a registrant calculated half-life of 2.7 days in Hanford sandy loam soil (pH 5.7) that was incubated in the dark at 25°C for 14 days. The major nonvolatile degradate, SD 6167, increased from 1.5% of the applied immediately posttreatment to a maximum of 20.0% at 5 days, then declined to 1.0% at 14 days. Unidentified organosoluble residues totaled 1.3-5.5% of the applied and included several minor degradates, each at <1% of the applied (<0.1 ppm). Unidentified water-soluble residues totaled 1.8-8.0% of the applied at 3 days posttreatment and included five unidentified degradates, each comprising <2% of the applied(<0.2 ppm). At 14 days posttreatment, CO_2 totaled 57.7% of the applied, organic volatiles were <0.5%, and unextracted residues were 26.5%. The majority of the unextracted residues was associated with the soil fulvic acid and humic acid fractions.

Residues in the organic and aqueous soil extracts should be identified if they are present at >0.01 ppm or 10% of the applied, whichever is less. After this study was reviewed, the registrant submitted additional information which showed that the unidentifed degradation products would be below the leevel of concern. The aerobic soil metabolism (162-1) data requirement is fulfilled.

f. Anaerobic Soil Metabolism (162-2)

Radiolabeled dicrotophos, at 10 ppm, degraded with a registrant-calculated half-life of approximately 7 days in Hanford sandy loam soil (pH 5.7). The test solution was incubated in the dark under anaerobic conditions (flooding plus nitrogen atmosphere) at 25°C for 33 days following 3 days of aerobic incubation. Dicrotophos comprised 52.1% of the applied immediately prior to flooding, 17.7% at 11 days and 2.6% at 33 days postflooding. SD 6167 was 13.9% of the applied immediately prior to flooding and increased to 47.9% by 33 days postflooding. SD 11733 was identified in the floodwater at a maximum of 12.7% of the applied at 33 days postflooding. In the floodwater, unidentified residues totaled 5.5-9.8% of the applied. In the soil extracts, unidentified organic residues were a maximum of 4.6% of the applied; this radioactivity consisted of several minor degradates. Unidentified water-soluble residues totaled a maximum of 8.0% of applied at 3 days posttreatment with five unidentified compounds, each at <0.2 ppm. At 33 days postflooding, CO_2 totaled 18.0% of the applied, organic volatiles were <0.5% and

unextracted soil residues were 6.2%.

The anaerobic soil metabolism data requirement is partially acceptable. The registrant needs to provide additional information concerning the persistence of the major degradate SD 6167 under anaerobic conditions (MRID 00160826).

g. Aerobic Aquatic Metabolism (162-4)

The environmental fate properties of dicrotophos indicate that it may be persistent in neutral and acidic waters and has the potential to move into surface water and shallow ground water. For this reason, EFED is requiring the registrant to submit an aerobic aquatic metabolism study to provide a more realistic assessment of dicrotophos concentrations in surface water.

ii.

a. Leaching and Adsorption/Desorption (163-1)

The registrant submitted two mobility studies. The first study was a soil adsorption/desorption study which showed that radiolabled dicrotophos, at 0.1-10 ppm, was very mobile in sand, sandy loam, silt loam, and clay soils with Freundlich K_{ads} values of 0.07-3.58. The soil:0.1 N calcium chloride solution slurries (1:5 ratio) were equilibrated in the dark at 25°C for 24 hours during adsorption and for 2 hours during each of three desorption steps. Freundlich K_{ads} values were 0.07 for the sand soil, 0.40 for the sandy loam soil, 0.92 for the silt loam soil, and 3.58 for the clay soil. Respective K_{oc} values were 11, 53, 40, and 187. Freundlich K_{des} values were 0.55 for the sandy loam soil, 1.15 for the silt loam soil, and 3.9 for the clay soil. A K_{des} value could not be determined for the sandy soil because insufficient dicrotophos had been adsorbed. (MRID 00160828).

In the second mobility study, sandy loam soil at pH 5.7 was treated with an aqueous solution of radiolabeled dicrotophos (10 ppm) and incubated in the dark at 25°C for 14 days. Soil extracts were analyzed using thin layer chromatography (TLC) at 3 and 14 days. Dicrotophos was highly mobile in the sandy soil with an Rf of 1.00; of intermediate mobility in the sandy loam and silt loam soils with Rf values of 0.52 and 0.44, respectively; and of low mobility in the clay soil with an Rf of 0.23. The major degradate SD 6167 was of high mobility in all four soils, with Rf values of 1.00 for the sand soil and 0.90-0.92 for the remaining soils. Dicrotophos was generally less mobile than trichloroacetic acid (TCA) and 2,4-D; approximately as mobile as atrazine; and more mobile than diuron and DDT. SD 6167 was approximately as mobile as TCA and generally more mobile than 2,4-D, atrazine, diuron, and DDT (MRID 00160829).

b. Laboratory Volatility (163-2)

Vinyl-labeled (1-14C)cis-dicrotophos at a nominal application rate of 8.2 ppm, did not volatilize from sandy loam soil incubated in darkness at 30°C for 7 days. The test substance used was equivalent to the end-use formulation. The soil was moistened to 75% of soil moisture

content at 0.33 bar, and the air flow rate was 50 mL/min. The parent compound was not present in the volatile traps following 7 days incubation. Radiolabeled volatiles were attributed to aerobic soil metabolism. Total radioactivity volatilized was 25.7% of the applied at 7 days with 25.6% identified as CO_2 and 0.1% as organic volatiles.

The registrant reported the vapor pressure of dicrotophos as 9.3 mPa at 20 C, which is equivalent to 7.0×10^{-5} mm Hg. The laboratory volatility (163-2) data requirement is fulfilled (MRID 43500401).

iii. Accumulation

a. Fish

Rainbow trout were treated with monocrotophos (technical grade) at 0.5 ppm for 31 days in a static exposure system (55-58 F). At 3- to 4-day intervals, the fish were transferred into a new tank of monocrotophos-treated water. After 31 days of exposure, the fish were transferred into a pesticide-free water system. Water and fish samples were collected and analyzed by LSC.

Monocrotophos did not accumulate in rainbow trout exposed to 0.5 ppm monocrotophos. In the fish tissues at all sampling intervals, monocrotophos was <0.03 ppm, SD-12657 was <0.03 ppm, and SD-11319 was <0.02 ppm. The concentration of monocrotophos in the water was 0.43-0.51 ppm during the exposure period.

The study was performed with monocrotophos instead of dicrotophos, and the test system was static. The source of the trout and the acclimation procedures were not described. In addition the test water was not characterized. The study is unacceptable (MRID 00155661). If the registrant wants to waive this study based upon the K_{ow}, then they need to submit a formal waiver request to the Agency.

iv. Terrestrial Field Dissipation (164-1)

The registrant submitted four terrestrial field dissipation studies. The first two studies (MRID 00115294) submitted in 1973 were unacceptable because the experimental methodology was incomplete, the sampling intervals were too infrequent, and degradates were not analyzed. In this unacceptable study, dicrotophos dissipated with a half-life of <30 days from a plot of silt loam soil that was treated with 5 lb ai/A with dicrotophos in Louisiana. In the upper 6 inches of the soil, dicrotophos was 2.1 ppm immediately posttreatment, 1.8 ppm at 7 days, and <0.01 ppm at 30 and 90 days. Dicrotophos was not detected in the deeper soil depths at any sampling interval.

In a second set of field studies (MRID 41114301) submitted in 1989, dicrotophos dissipated with a half-life of 2.2 days from silt loam soil in Mississippi that was treated three times at 7-day intervals with dicrotophos at 8 oz ai/A/application (total of 24 oz ai/A). Bidrin 8, 8 lb ai/gal,, water miscible, was sprayed at two sites in Mississippi and Georgia that had been planted to cotton. In Mississippi, dicrotophos was applied to a plot of silt loam soil (pH 6.2) and soil

cores were collected to a depth of 36 inches from treated and control plots. At the Georgia site, dicrotophos was applied to a sandy loam soil (pH 6.8) and analyzed in a similar manner.

At the Mississippi site, dicrotophos was found at 0.17-0.22 ppm immediately after the first application in the upper 6 inches of soil; at 0.10-0.13 ppm after the second application; and 0.37-0.42 ppm after the third application. Dicrotophos was 0.11-0.28 ppm 2 days after the third application, 0.13-0.15 ppm at 3 days, 0.03-0.06 ppm at 5 and 14 days, and <0.02 ppm at 31-60 days. Dicrotophos was not detected below the 6-inch depth at any sampling interval. The soil samples were not analyzed for any degradates, the test sites were inadequately described, and the sampling procedures were incomplete.

At the Georgia site, dicrotophos was found at 0.11 and 0.13 ppm immediately following the first application; 0.03 and 0.04 ppm after the second application; and <0.02 and 0.03 ppm after the third application. Dicrotophos was not detected at any subsequent sampling interval and was not detected below the 6 inches. The data from this second site are too uncertain to use. The initial concentration of dicrotophos in the soil was too low to establish a pattern of decline, and dicrotophos was detected in only one of the two samples collected immediately after the third application. In addition, the descriptions of the sampling procedures and test sites were incomplete and the formation and decline of degradates were not reported.

The terrestrial field dissipation (164-1) data requirement is not fulfilled. The Mississippi study is classified as supplemental and can be upgraded if the registrant provides additional data concerning the formation and decline of the degradates. The data from the Georgia study are too uncertain and cannot be resolved by submission of additional data. In addition to upgrading the Mississippi study, the registrant needs to submit an additional new study representative of the use site (Mississippi River Valley) and under actual use conditions.

v. Spray Drift

The registrant did not submit spray drift studies for dicrotophos. Droplet size spectrum (201-1) and drift field evaluation (202-1) studies are required for products which may be applied by aircraft and orchard airblast equipment because of the concern for potential risk to nontarget species. To satisfy these requirements, though, the registrant has joined the Spray Drift Task Force (SDTF) which is characterizing spray droplet drift potential. Until the SDTF report is released, the Agency will rely on previously submitted spray drift data and open literature for off-target drift rates. The rates are 1% of the applied spray volume from ground applications and 5% from aerial and orchard airblast applications at 100 feet downward.

c. Terrestrial Exposure Assessment

The Agency used the model of Hoerger and Kenega (1972), as modified by Fletcher et al. (1994) to estimate pesticide concentrations on selected avian or mammalian food items immediately after application. Table 1 gives the predicted 0-day maximum and mean residues of a

pesticide that are expected to occur immediately following a direct single application at 1 lb ai/A.

Table 1. Estimated Environmental Concentrations on Avian and Mammalian Food Items (ppm) Following a Single Application at 1 lb ai/A)

Food Items	EEC (ppm) Predicted Maximum Residue[1]	EEC (ppm) Predicted Mean Residue[1]
Short grass	240	85
Tall grass	110	36
Broadleaf/forage plants, and small insects	135	45
Fruits, pods, seeds, and large insects	15	7

[1] Predicted maximum and mean residues are for a 1 lb ai/a application rate and are based on Hoerger and Kenaga (1972) as modified by Fletcher *et al.* (1994).

EPA estimated peak residues (EEC's) for a single application of dicrotophos on cotton by linear extrapolating the above values for a 0.5 lb ai/A application rate (i.e. multiplying the above values by 0.5). For multiple applications, the Agency assumed three applications with 5-day intervals between applications. The peak EEC was the cummulative residue value predicted immediately following the third application. The FATE model, which calculates cummulative residues assuming a first order dissipation after application, was used to estimate these peak residues. The Agency used 2.7 days, the half-life for soil aerobic metabolism, as an estimate of the half-life of dicrotophos on foliage and insects. Although the half-life of dissipation of dicrotophos from foliage is unknown, data for a closely related chemical, monocrotophos, indicates a foliage half-life of between 1.3 and 3.4 days (Willis and McDowell, 1987).

For assessing chronic risk to birds and mammals, we assumed an exposure period of 30 days. The FATE program was again used to estimate daily residue values. The agency obtained maximum 30-day average EECs by averaging daily maximum residues for the first 30 days, beginning with the first application. Acute and chronic EEC's are presented in Table 2.

Table 2. Acute and Chronic Terrestrial EEC's for Single and Multiple Applications of Dicrotophos

Site	Use Rate (lbs ai/A)	Number of Applications	Food Items	Peak EEC (ppm)	30-day Mean EEC (ppm)
Cotton	0.5	1	Short grass	120	18
			Tall grass	55	8.1
			Broadleaf plants/Insects	68	10
			Seeds	7.5	1.1
Cotton	0.5	3	Short grass	160	53
			Tall grass	74	24
			Broadleaf plants/Insects	92	30
			Seeds	11	3.3

d. Water Resource Assessment

i. Ground Water

Dicrotophos has a low binding affinity to soil (K_{ads} = 0.07-3.58 ml/g) and is likely to be found in the water column. It is very mobile in adsorption/desorption studies and persistent in abiotic hydrolyis studies at acidic and neutral pH's..

The SCI-GROW II model was used to estimate a screening concentration of dicrotophos under "worst case" conditions. SCI-GROW provides a screening concentration, an estimate of likely ground water concentrations if the pesticide is used at the maximum allowed label rate in areas with ground water exceptionally vulnerable to contamination. In most cases, a majority of the use areas will have ground water that is less vulnerable to contamination than the areas used to derive the SCI-GROW estimate. The SCI-GROW model is based on scaled ground water concentration from ground water monitoring studies, environmental fate properties and application rates. The model is based on permeable soils that are vulnerable to leaching and on shallow ground water (10-30 feet).

Results from this model indicate that the maximum estimated concentration of dicrotophos in ground water is not expected to exceed 0.0048 ppb for the majority of use sites. It's important to note that these results are below the detection limits (0.1 ppb) of the model. Based upon these modeling results, dicrotophos is not expected to pose a significant ground water problem. The following parameters were used for estimating concentrations of dicrotophos in ground water.

Parameter	Value	Source
Aerobic Soil Half-life	2.7 days	MRID 00160826

Soil K_{oc}	11 ml/g	MRID 00160829

ii. Surface Water

The Agency calculates EECs using the GENeric Expected Environmental Concentration Program (GENEEC). The EECs are used for assessing acute and chronic risks to aquatic organisms. Acute risk assessments are performed using peak EEC values for single and multiple applications. Chronic risk assessments are performed using the 21-day EECs for invertebrates and 56-day EECs for fish.

The GENEEC program uses basic environmental fate data and information on application methods to estimate the aquatic EECs following application of a pesticide. The model calculates EECs of the pesticide transported from a 10-ha treatment area to a 1-ha, 2-m deep pond. The model estimates loading from agricultural runoff, taking into account adsorption to soil, soil incorporation, and degradation in soil while the pesticide is in the field (i.e., before the first runoff event), as well as adsorption to sediments and aquatic degradation once it reaches the pond. The model also accounts for direct deposition of spray drift into the pond. Spray drift deposition is assumed to be 1% and 5% of the application rate for ground and aerial applications, respectively. For this pesticide, aerobic aquatic metabolism was not taken into account because no data were available to estimate the half-life. This model was run to represent one application and two applications with a 120-d application interval.

In addition to GENEEC, the Agency used PRIZM-EXAMS to calculate refined EECs. The Pesticide Root Zone Model (PRZM, version 3.1) simulates pesticides in field runoff, while the Exposure Analysis Modeling System (EXAMS, version 2.97-5) simulates pesticide fate and transport in an aquatic environment (one hectare body of water, two meters deep). EECs are tabulated below.

Table 2. Estimated Environmental Concentrations (EECs) of Aquatic Exposure for Use of Dicrotophos on Cotton

Analytical Model	Application Method	Application Rate (lbs ai/A)	# of Application (Interval between Applications)	Peak EEC (ppb)	21-day Average EEC (ppb)	60-day Average EEC (ppb)
GENEEC	Ground spray	0.5	3 (5 days)	37.0	33.6	28.7
	Aerial spray	0.5	3 (5 days)	38.7	35.2	30.0
PRZM/EXAMS	Aerial spray	0.5	3 (5 days)	21.3	8.51	3.46

Aerial or ground application of dicrotophos may result in direct spray drift deposition into surface waters adjoining target use sites. The drift potential for aerial and ground spray is assumed to be equivalent to 5% of applied and 1% of applied, respectively.

Environmental fate data indicate that dicrotophos is potentially mobile (K_{oc} = 11) and persistent in aqueous environments, especially at neutral and acidic pH's. Tier 1 GENEEC

modeling indicate that dicrotophos may reach surface waters at a peak concentration of 36.95 μg/L. Other GENEEC values are listed below.

Application Method	Peak GEEC	4-day average	21-day average	56-day chronic
Ground	36.95 ppb	36.43 ppb	33.59 ppb	28.65 ppb
Aerial	38.67 ppb	38.14 ppb	35.18 ppb	29.99 ppb

The input parameters for GENEEC modeling are as follows:

Parameter	Value	Source
Application rate	0.5 lb a.i./A 3X/season	label
Soil K_{oc}	11 ml/g	MRID 00160829
Aerobic Soil Half-life	2.7 days	MRID 00160826
Photolysis Half-life	stable	MRID 00160824
Aerobic Aquatic Half-life	stable	No available data; assumed to be stable
Hydrolysis	72 days at pH 7	MRID 00160823
Water Solubility	11,990 ppm	EFGWB One-Liner

Tier II PRZM-EXAMS modeling was also conducted for cotton using a Loring silt loam in the southern Mississippi Valley. The PRZM-EXAMS upper 10th percentile peak EEC was 21.26 μg/L, while the yearly upper tenth percentile was 0.614 ug/L. Although dicrotophos could pose an acute surface water problem, it does not appear to accumulate. Other PRIZM values and input parameters are listed in Appendix IV.

iii. Drinking Water

Dicrotophos is not regulated under the Safe Drinking Water Act (SDWA), and EPA's Office of Water has not established a Maximum Contaminant Level (MCL) for dicrotophos. Estimated environmental concentrations of dicrotophos are based solely on ground and surface water models.

STORET monitoring data did not show any detections in ground or surface water for dicrotophos or monocrotophos (a plant metabolite of dicrotophos) above the reported detection limits. Detection limits varied from 1 x 10^{-5} ppm to 1 ppb. Approximately 236 sites were sampled for dicrotophos in Mississippi, California, Virginia, and New Mexico. These sites

included 96 wells, 5 lakes, and 126 streams. Storet data also included 1017 sampling sites for monocrotophos in California, Florida, Georgia, Idaho, Mississippi, New Mexico, Virginia, and Washington. These sites included 353 groundwater sites and 664 surface water sites.

In EPA's Pesticides in Groundwater Database, dicrotophos was not found in any of the 14 wells which were sampled in California between 1984-1987. The USGS NAWQA program did not sample for either dicrotophos or its degradates in either ground or surface waters.

3. Ecological Toxicity Assessment

a. Toxicity to Terrestrial Animals

i. Birds, Acute and Subacute

An acute oral toxicity study using the technical grade of the active ingredient (TGAI) is required to establish the toxicity of dicrotophos to birds. The preferred test species is either the mallard (a waterfowl) or the northern bobwhite (an upland gamebird). Results of acute oral testing with birds are given in Table 3.

Table 3. Acute Oral Toxicity to Birds

Species	% ai	LD_{50} (mg/kg)	Toxicity Category	MRID No. Author/Year	Study Classification[1]
Mallard (*Anas platyrhynchos*) (male)	98	4.24	Very highly toxic	00160000 Hudson, Tucker, and Haegele, 1984 (also U.S. Fish and Wildlife Service, 1966)	Core
Canada Goose (*Branta canadensis*)	98	2.28	Very highly toxic	00160000 Hudson, Tucker, and Haegele, 1984	Core
Domestic goose	Technical	1.22	Very highly toxic	MRID 00013439 Doyle and Elsea, 1963	Supplemental
California quail (male) (*Callipepla californica*)	98	1.89	Very higly toxic	00160000 Hudson, Tucker, and Haegele, 1984 (also U.S. Fish and Wildlife Service, 1996)	Core
Chuckar (*Alectoris chukar*)	98	9.63	Very highly toxic	00160000 Hudson, Tucker, and Haegele, 1984 (also U.S. Fish and Wildlife Service, 1996)	Supplemental[3]
Japanese quail (male) (*Coturnix coturnix japonica*)	98	4.32	Very highly toxic	00160000 Hudson, Tucker, and Haegele, 1984 (also U.S. Fish and Wildlife Service, 1996)	Supplemental[3]
Ring-neck pheasant (male) (*Phasianus colchicus*)	98	3.21	Very highly toxic	00160000 Hudson, Tucker, and Haegele, 1984 (also U.S. Fish and Wildlife Service, 1996)	Core
Sharp-tailed grouse (male) (*Tympanuchus phasianellus*)	98	2.31	Very highly toxic	00160000 Hudson, Tucker, and Haegele, 1984	Supplemental[3]
House sparrow (male) (*Passer domesticus*)	98	3.00	Very highly toxic	00160000 Hudson, Tucker, and Haegele, 1984 (also U.S. Fish and Wildlife Service, 1996)	Core
House finch (*Carodacus mexicanus*)	98	2.83	Very highly toxic	00160000 Hudson, Tucker, and Haegele, 1984	Supplemental[2]
Rock dove (*Columba livia*)	98	2.00	Very highly toxic	00160000 Hudson, Tucker, and Haegele, 1984	Supplemental
Rock dove (*Columba livia*)	98	2.38	Very highly toxic	U.S. Fish and Wildlife Service, 1996	Supplemental

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline).
[2] Sample size was small (N=8).
[3] Test species not acceptable for fulfilling EPA test guidelines.

Since the LD_{50}'s are less than 10 mg ai/kg, dicrotophos is classified as very highly toxic to

birds on an acute oral basis. Birds of several different families show very similar sensitivity to dicrotophos. The lowest LD_{50} of 1.89 mg ai/kg for the California quail will be used in the risk assessment. The guideline (GLN 71-1) is fulfilled (MRID 00160000).

Published literature provide information on the effects of age on the acute oral toxicity of dicrotophos to birds (Table 4). The results of Grue and Shipley (1983) indicate that young of atricial passerine species are more sensitive than adults (5-day-old starling nestlings were approximately twice as sensitive as adult starlings). The results of Hudson *et al.* (1972), however, indicate that the young of precocial waterfowl were not more sensitive than adults. In fact, 7-day-old and 30-day-old mallards were found to be less sensitive than 6-month-old mallards. The LD_{50}'s reported for 6-month mallards and 5-day starlings were similar to most values obtained in other tests with adult birds, whereas the LD_{50}'s reported for younger mallard and older starlings were slighlty greater than those reported in the other tests.

Table 4. Effect of age on acute oral toxicity of dicrotophos to birds.

Species	Age (Sex)	LD_{50} (mg/kg)	95% Confidence Interval	Reference
Mallard (*Anas platyrhynchos*)	36 hr	6.17	3.33-11.4	Hudson *et al.* 1972
	7 d	7.03	5.30-9.31	
	30 d	6.73	5.53-8.19	
	6 mo	4.14	3.33-5.16	
Starling (*Sturnus vulgaris*)	5 d	4.92	3.98-6.48	Grue and Shipley, 1983
	15 d	9.59	7.60-12.1	
	>1 yr (male)	8.37	6.30-10.5	
	>1 yr (female)	8.47	5.54-11.4	

Two subacute dietary studies using the TGAI are required to establish the toxicity of dicrotophos to birds. The preferred test species are the mallard and the northern bobwhite. Results of these tests are given in Table 5.

Table 5. Subacute Dietary Toxicity to Birds

Species	% ai	5-Day[1] LC_{50} (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Northern bobwhite (*Colinus virginianus*)	NA	13	Very highly toxic	MRID 00013707 Gough, Shellenberger, and Escuriex,1967	Supplemental
Japanese quail (*Coturnix coturnix japonica*)	NA	52	Very highly toxic	MRID 00013707 Gough, Shellenberger, and Escuriex,1967	Supplemental
Japanese quail (*Coturnix coturnix japonica*)	85.0	32	Very highly toxic	MRID 00022923 Hill, Heath, Spann, and Williams, 1975	Suplemental
Japanese quail (*Coturnix coturnix japonica*)	NA	38 (1 days) 38 (7 days) 47 (14 days) 21 (21 days)	Very highly toxic	Acc. No. 248514 Hill, 1981	Supplemental
Ringed-neck pheasant (*Phasianus colchicus*)	85.0	44	Very highly toxic	MRID 00022923 Hill, Heath, Spann, and Williams, 1975	Core
Ringed-necked pheasant[2] (*Phasianus colchicus*)	85.0	44.8	Very highly toxic	Acc. No. 248514 Hill, 1981	Supplemental
Mallard (5 days old) (*Anas platyrhynchos*)	85.0	94	Highly toxic	MRID 00022923 Hill, Heath, Spann, and Williams, 1975	Core
Mallard (10 days old) (*Anas platyrhynchos*)	85.0	144	Highly toxic	MRID 00022923 Hill, Heath, Spann, and Williams, 1975	Core
Mallard[2] (*Anas platyrhynchos*)	85.0	101.8	Highly toxic	Acc. No. 248514 Hill, 1981	Supplemental

[1] Test organisms observed an additional three days while on untreated feed.
[2] The reported result is the mean value of results of five replicate test run at different times.

Since several of the LC_{50}s are less than 50 ppm ai, dicrotophos is classified as very toxic to birds on a subacute dietary basis. The LCD_{50} of 32 ppm ai for the Japanese quail was used in the risk assessment for dicrotophos. This result was from a study that was classified as supplemental solely because it did not use a recommended test species. Although a study with the northern bobwhite yielded a lower LC_{50}, the accuracy of this result is less certain because little information is known on the test protocol. The guideline (GLN 71-2) is fulfilled (MRID 00022923).

ii. Birds, Chronic

Avian reproduction studies using the TGAI are required for dicrotophos because birds may be subject to repeated exposure to the pesticide during the breeding season and information derived from mammalian reproduction studies indicates reproduction in terrestrial vertebrates may be adversely affected by the anticipated use of the product (rat reproductive NOAEL = 2 ppm). The preferred test species are mallard duck and bobwhite quail. Results of avian reproduction tests are given in Table 6.

Table 6. Reproductive Toxicity to Birds

Species/ Study Duration	% ai	NOEC (ppm ai)	LOEC (ppm ai)	LOEC Endpoints	MRID No. Author/Year	Study Classification
Northern bobwhite *(Colinus virginianus)*	87.65	0.50	1.5	Egg production and food consumption	44005502 Cameron, 1996	Core
Mallard duck *(Anas platyrhynchos)*	87.65	1.0	3.0	Female body weight	44005501 Cameron, 1996	Core
		3.0	10	Egg production, embryo viability, hatching production and survival, egg shell thickness,and male body weight		

The northern bobwhite was the more sensitive test species. These results indicate that reproduction impairment begins to occur at dietary concentrations between 0.50 and 1.5 mg ai/kg food. The guideline (GLN 71-4) is fulfilled (MRIDs 44005501 and 44005502).

iii. Mammals, Acute and Chronic

Wild mammal testing is not required for dicrotophos. Rat toxicity values obtained from the Agency's Health Effects Division (HED) will substitute for wild mammal testing. Acute and chronic rat toxicity data relevant to ecological effects are given in Table 7.

Table 7. Toxicity to Mammals

Species	% ai	Test Type	Toxicity Value	Affected Endpoints	MRID/Acc. No. (Grade)
Rat (*Rattus norvegicus*)	88.3	Acute oral	LD_{50}=9.0 mg/kg	Mortality	261098 (Minimal)
Rat (*Rattus vorvegicus*)	88.3	Acute dermal	LD_{50}=664 mg/kg	Mortality	261098 (Minimal)
Rat (*Rattus norvegicus*)	89.7	Develpmental	NOEL= 0.5 mg/kg/d LOEL=1.0 mg/kg/d	Body weight gain and fasciculation	263684 (Minimal)
			NOEL>2.0 mg/kg/d	development	
Rat (*Rattus norvegicus*)	Tech.	Reproduction, 1-generation	NOEL=3.0 ppm LOEL=30 ppm	Female fertility and offspring viability	00013446 (Supplemental)
Rat (*Rattus norvegicus*)	Tech.	Reproduction, 3-generation	NOEL=2 ppm LOEL=5 ppm	Pup survival	00013446 (Supplemental)

The results indicate that dicrotophos is very highly toxic to small mammals on an acute oral basis. Dicrotophos appears to be slightly less toxic to mammals than to birds. Dicrotophos affects mammalian reproduction at dietary concentrations of 5 ppm and greater.

iv. Insects

A honey bee acute contact study using the TGAI is required for dicrotophos because its

use on cotton will result in honey bee exposure. Results of this test are given in Table 8.

Table 8. Acute Contact Toxicity to Nontarget Insects

Species	% ai	LD50 (μg/bee)	Toxicity Category	MRID No. Author/Year	Study Classification
Honey bee *(Apis mellifera)*	Technical	0.076	Highly toxic	05001991 Stevenson, 1978	Core

The results indicate that dicrotophos is highly toxic to bees on an acute contact basis. Additional information is provided by other nonguideline studies. In one study, a solution of dicrotophos was perpared at a concentration of 0.50 lb ai/100 gal and applied to adult *Amblyseius hibisci* at a dose of 6.44 μg/cm^2. In this study, dicrotophos was given a toxicity rating of "high", meaning the LT_{50} was less than 1 day (MRID 05004148). In an acute dietary study, dicrotophos was added to honey at a concentration of 477 ppm and fed to four species of beneficial insects: *Lindorus lophanthae*, *Cryptolaemus montrouzieri*, *Aphytis melinus*, and *metaphycus luteolus*. The toxicity rating was "high" for all species (LT_{50} < 1 day) (MRID 05005640). Dicrotophos has also been shown to be highly toxic to the alkali bee (*Nomai melanteri*), with an oral LD_{50}s of 1.75 μg/g for males and 1.52 μg/g for females (MRID 05015679). The guideline (GLN 141-1) is fulfilled (MRID 05001991).

A honey bee toxicity of residues on foliage study using the typical end-use product is required for dicrotophos because its use on cotton will result in honey bee exposure and the acute contact honey bee LD_{50} is less than 1 *ug*/bee. This test showed that when dicrotophos is applied at 0.5 lb/A, residues remaining on foliage are toxic to bees two days after application. The observed mortality to honey bees, alkali bees, and leafcutter bees are 7%, 29%, and 40%, respectively (MRID 05000837). Other studies have shown that residues of dicrotophos are toxic to bees and other beneficial insects for up to 7 days when applied to white clover at 0.45 lb ai/A (MRID 05009353) and for up to 16 days when applied to raspberries at 0.43 lb ai/A (MRID 05013577). The guideline (GLN 141-2) is fulfilled (MRIDs 05000837 and 05009353).

v. Terrestrial Field Studies

Field Studies for Use on Cotton:

Two field studies concerning the use of dicrotophos on cotton were conducted to fulfill a previous data requirement. One study was conducted in southwestern Arizona (MRID 40873701) and the other study was conducted in southeastern Alabama (MRID 40917001). Although both studies were classified as supplemental, meaning that they were not adequate for fulfilling the previous guideline requirement, they did provide useful information on risk posed to wildlife.

The study in Arizona (MRID 40873701; Palmer *et al.*, 1988) was conducted along the Gila River in Yuma county, near the city of Yuma. Rapirian habitat along the Gila River,

dominated by salt cedar, provides good wildlife habitat in this region. Three applications of dicrotophos (Bidrin 8 Insecticide), each at a rate of 0.2 lb ai/A, were aerially applied to eight treated fields. Two untreated cotton fields served as controls. Dicrotophos was tank mixed with malathion (1 lb ai/A) during the first two applications and with chlorpyrifos (0.7 lb ai/A) during the third application. Avian abundance estimates were made by recording all the birds seen and heard in 100-m radius circular plots. Observations were also made of wildlife use of the cotton fields. Carcass searching was conducted prior to application (2 man-hours) and from the first application until 14 days after the last application (330 man-hours). Searching was conducted in transect lines that ran in the field interior, ran along the field perimeters, and radiated out from the field edge into adjacent habitat. The field perimeter and randomly selected transects in the cotton fields and adjacent habitat were searched each day. Recovered carcasses were analyzed for dicrotophos residues. Trials were conducted to measure search efficiency and carcass removal rates. Radio transmitters were successfully attached to 41 free-ranging quail, which were then monitored for mortality after dicrotophos treatments. Finally, samples of crop, foliage, water, and invertebrates were collected and sampled for dicrotophos residues.

The conclusions of the avian census was that the avian fauna in the study area was "relatively diverse and had high species richness and abundance." There were 4,476 observations of birds of 64 identifiable species. Twenty-eight percent of the observations, comprising 21 species, were of birds within the cotton field. Over two-thirds of observations of birds in cotton were of the red-winged blackbird. These results indicate that there was considerable use of cotton fields by birds, although the methods used were not adequate to provide definitive crop use data.

Carcass searching yielded 56 vertebrate casualties, which included deaths and individuals displaying abnormal behaviors. Of these, 5 were considered to be definitely treatment-related (i.e., contained dicrotophos residues in carcass), 8 were considered to be possibly treatment-related, and 22 were considered to be not treatment-related. Of the 13 casualties that were known or suspected of being treatment-related, 10 were Gambel's quail and 3 were horned larks. The cause of death for the remaining 18 casualties could not be determined. Thus, the number of observed wildlife mortalities that were treatment-related were between 5 and 31. It is important to realize that the carcasses found in no way represents the total mortality that occured in the study. Due to reentry restrictions, field interiors were not searched for the first 48 hours after treatment. Thus, the remains of animals that died in cotton fields immediately after treatment could have been removed by scavengers. Futhermore, daily carcass searching in the field interior and in adjacent habitat was conducted only along randomly selected transect lines; much of these areas were not search. Finally, the search efficiency trials indicate that searchers were able to find only 42-66% of carcasses present within the searched areas. Therefore, the number of treatment related deaths were likely much greater than the number of casualties observed.

Of the 41 radio-tagged Gambel's quail, 8 were found dead. The study authors believed that one death was treatment-related (dicrotophos residues detected in skin and feathers and in tissue) and a second death may have been treatment-related (dicrotophos residues detected in skin and feathers but not in tissue). Of the remaining six dead quail found, three were not believed to

be treatment-related, whereas the cause of death for the other three could not be determined because only feather spots were found. The feather spots could have been remains of birds that died from dicrotophos and were then taken by scavengers. Furthermore, treatment related effects were also observed in Gabel's quail that were not radiotagged. One severely debilitated quail was found to contain tissue residues of dicrotophos (0.08 ppm), six untagged quail were observed exhibiting abnormal behavior consistent with organophoshphate poisoning, and two feather spots of quail were found in cotton fields.

The study in Alabama (MRID 40917001; Sheeley *et al.*, 1988) was conducted on cotton fields in Lee, Macom and Russell counties in eastern Alabama. Climax vegetation in this area is oak-hickory forest. Dicrotophos (Bidrin 8 Insecticide) was applied using ground equipment. Two applications were made at a rate of of 0.5 lb ai/A per application, with six days between applications. Dicrotophos was tank mixed with chlordimeform and esfenvalerate during several applications, and methyl parathion, malathion, EPN, and profenofos were also applied prior to or during the study period. Six untreated cotton fields served as controls. The experimental design and methods were otherwise identical to the field study in Arizona, described above, with the exception that monitoring of radio-tagged birds was not conducted in the Alabama study.

The conclusions of the avian census was that the avian fauna in the study area was "diverse and had high species richness and abundance." There were 4,751 observations of birds of 72 identifiable species. Five percent of the observations, comprising 29 species, were of birds within the cotton field. The species most commonly observed in cotton fields were the ruby-throated hummingbird, the chimney swift, the purple martin, the indigo bunting and the common grackle. Several mammals, reptiles and amphibians were also observed using cotton fields. These results indicate that wildlife did use of cotton fields in this study, but the use by birds appears to be less than in the Arizona study.

Carcass searching yielded 35 vertebrate casualties, which included deaths and individuals displaying abnormal behaviors. Of these, 5 were considered to be definitely treatment-related (i.e., contained dicrotophos residues in carcass), 5 were considered to be possibly treatment-related, and 18 were considered to be not treatment related. The cause of death for the remaining 7 casualties could not be determined. Thus, the number of observed wildlife mortalities that were treatment-related were between 5 and 17. It is important to realize that the number of carcasses found in no way represents the total mortality that occured. Three carcasses of indigo buntings had dicrotophos residues of 0.09-0.51 ppm in tissue and 1.8-17 ppm on skin and tissue. One crow and one indigo bunting that were sacraficed after showing signs of poisoning also had dicrotophos residues in tissue (0.05-0.09 ppm) and on skin and tissue (1.4-3.5 ppm). In addition, a mourning dove, a common ground dove, and a crow exhibited behavior that was consistent with organophosphate poisonong but could not be captured. Carcasses of a shrew and a lizzard were also found near treated fields, but their cause of death could not be determined. As in the Arizona study, the number of treatment-related deaths were likely much greater than the number of casualties observed because of the following reasons: (1) field interiors were not searched for the first 48 hours after application, during which time carcasses could have been removed by scavengers, (2) only randomly selected transects were searched, and (3) search efficiency was

poor especially during the postapplication period (50% in adjacent habitat, 31% in field interior, and 15% along field perimeters).

These field studies show that typical use of dicrotophos on cotton in both the southwestern and southeastern United States creates a high risk of acute poisoning of birds and possibly other terrestrial wildlife. The study in Arizona clearly showed that the use of dicrotophos on cotton created a hazard to Gambel's quail and horned larks. This hazard occurred even when dicrotophos was applied at 0.2 lb ai/A, which is 60% lower than the current maximum label rate (0.5 lb ai/A). The study in Alabama also clearly showed that the use of dicrotophos on cotton at 0.5 lb ai/A created a hazard to birds, including indigo buntings, crows, and doves.

Other Field Studies:

Stromborg *et al*. (1988) studied the effects exposure to dicrotophos in young European starlings (*Sturnus vulgaris*). A dose of 6 mg/kg body weight of dicrotophos (purity=85%) was administered orally to 16 day-old nestlings. The effects on mortality, body weight, and age at fledging were measured in nestlings. The young birds were marked with wing tags and were observed after fledgling to determine effects on postfledging survival, habitat use, and flocking behavior. Prefledging survival was significantly lower in dicrotophos-dosed nestlings, which suffered a mortality rate of 18.5% during the first two days after dosing. Severe depression of brain cholinesterase activity in birds that died (mean = 93%) was evidence that the mortality was caused by exposure to dicrotophos. Dosed nestlings also lost significantly more body mass (-5.2%) compared to the controls (-1.4%) during the first two days after dosing. However, similar body weights were observed between dosed and control birds after this period. The age at fledging, postfleding survival, flocking behavior, and habitat use did not differ between dosed and control birds. These results suggest that exposure of nestlings to dicrotophos can cause mortality and weight lose, but nestlings that survive these acute effects suffer no serious long-term effects. It should be noted that possible effects related to inadequate parental care by adult birds exposed to dicrotophos was not evaluated in this study.

An unpublished field study (Simkover and Bishop, 1971, MRID 00013511) described the effects on wildlife from the application of dicrotophos (Bidrin) to a lemon orchard. Dicrotophos was aerially applied to one-half of a 20-acre orchard at the rate of 2 lb ai/A. Carcass searches were conducted in and around the orchard one and two days after application. On the day after treatment, 16 dead and 5 morbid birds were found on the study site. Nine more bird carcasses were found on the following days. All but one of the 30 affected birds were seed eaters, which lead the authors to conclude that the birds were exposed to dicrotophos through consumption of seed from the weeds present in the orchard. This supplemental field study was judged to be inadequate to fulfill guideline requirements because pre- and post-treatment surveys were insufficient to make any statistically sound comparisons between treated and control plots. Nevertheless, this study did demonstrate that significant bird mortality can occur when dicrotophos is used at this high rate (four times the maximum single-application rate for cotton).

An unpublished field study (McEwen and Haegele, 1968, MRID 00013702) described the

effects on wildlife from the use of dicrotophos (Bidrin) applied on rangeland at a rate of 0.125 lb ai/A. This supplemental field study could not be adequately evaluated because the methodology was incomplete. In this study, a census of birds showed that the number of birds present significantly decreased on a treated area 4 days after spraying, whereas the number in an untreated areas did not change. The study did not determine if the decrease in birds was due to mortality or to birds leaving the area. A carcass of a loggerhead shrike was also found in the treatment area after spraying. The reseachers monitored four nests in the treated area and three nests in the control areas. The eggs were either abandoned or the nestlings disappeared in all four nests in the treated area after spraying. None of the three nests failed in the control area. While these results suggest that spraying of dicrotophos had an adverse impact on bird abundance and nest success, the study failed to determine the cause of these impacts since no measurement of pesticide exposure was conducted. Besides direct toxicity to the birds, the results could also be explained by a reduction in food resources (arthropods), disturbance caused during pesticide application, or repellancy of the pesticide to birds.

b. Toxicity to Freshwater Animals

i. Freshwater Fish, Acute

Two freshwater fish toxicity studies using the TGAI are required to establish the toxicity of dicrotophos to fish. The preferred test species are rainbow trout (a coldwater fish) and bluegill sunfish (a warmwater fish). Results of these tests are given in Table 9.

Table 9. Acute Toxicity to Freshwater Fish

Species/ (Flow-through or Static)	% ai	96-hour LC50 (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Rainbow trout *(Oncorhynchus mykiss)* static	90	6.3	Moderately toxic	40098001 Mayer and Ellersieck, 1986	Core
Bluegill sunfish *(Lepomis macrochirus)*	80	24.2	Slightly toxic	40098001 Mayer and Ellersieck, 1986	Core
Bluegill sunfish *(Lepomis macrochirus)*	82	<28.0	At least slightly toxic	70771? Animal Biology Laboratory, 1970	Supplemental
Channel catfish (*Ictalurus punctatus*)	90	7.66	Moderately toxic	40098001 Mayer and Ellersieck, 1986	Core

Since two of the LC_{50}s fall in the range of >1 to 10 ppm, dicrotophos is classified as moderately toxic to freshwater fish on an acute basis. The guideline (GLN 72-1) is fulfilled (MRID 40098001).

ii. Freshwater Fish, Chronic

A freshwater fish early life-stage test using the TGAI is not required for dicrotophos

because aquatic acute LC_{50}'s for freshwater fish are greater than 1 mg/L and the EEC in water is less than 0.01 of the acute LC_{50} values.

iii. Freshwater Invertebrates, Acute

A freshwater aquatic invertebrate toxicity test using the TGAI is required to establish the toxicity of dicrotophos to aquatic invertebrates. The preferred test species is *Daphnia magna*. Results of this test are given in Table 10.

Table 10. Acute Toxicity to Freshwater Invertebrates

Species, Study Type	% ai	EC_{50} (ppb ai)		Toxicity Category	MRID No. Author/Year	Study Classification
		48-hr	96-hr			
Waterflea *(Daphnia magna)*, Flow-through	87.65	12.7	--	Very highly toxic	MRID 43787901 Davis and Cunningham, 1995	Core
Waterflea (*Simocephalus serrulatus*), Static	80.0	270	--	Highly toxic	MRID 4009801 Myer and Ellersieck, 1986	Core
Crayfish (*Orconectes nais*), Static	80.0	--	6000	Moderately toxic	MRID 4009801 Myer and Ellersieck, 1986	Supplemental
Scud (*Gammarus fasciatus*), Static	80.0	--	2600	Moderately toxic	MRID 05017538 Sanders, 1972	Supplemental[1]
Scud (*Gammarus lacustris*), Static	80.0	790	540	Highly toxic	MRID 05009242 Sanders, 1969	Supplemental[1]
Stonefly (*Pteronarcys californica*), Static	80.0	1900	430	Highly toxic	MRID 05010360 Sanders and Cope, 1968	Supplemental[2]

[1] Test was conducted with mature organisms.

[2] Test was conducted with organisms in the second year-class.

Since the EC_{50} for *Daphnia magna* is less than 100 μg/L, dicrotophos is classified as very highly toxic to freshwater invertebrates on an acute basis. However, results for other aquatic invertebrates indicate toxicity in the moderately toxic to highly toxic range. The tests conducted with the scud and stonefly might underestimate toxicity because they were not conducted with the most sensitive life-stage. The guideline (GLN 72-2) is fulfilled (MRIDs 43787901 and 4009801).

iv. Freshwater Invertebrate, Chronic

A freshwater aquatic invertebrate life-cycle test using TGAI dicrotophos has not been submitted to the Agency. This test is required for dicrotophos since the end-use product is expected to be transported to water from the intended use site, and the following conditions are met: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent, (2) the *Daphnia magna* acute EC_{50} is less than 1 mg/L (EC_{50}=12.7 μg ai/L) and (3)

the EEC in water (21.3μg/L) is greater than 0.01 *Daphnia magna* acute EC_{50}. The preferred test species is *Daphnia magna*. This test guideline (72-4) is not fulfilled.

v. Freshwater Field Studies

Freshwater field studies are not required for dicrotophos.

c. Toxicity to Estuarine and Marine Animals

i. Estuarine and Marine Fish, Acute

Acute toxicity testing with estuarine/marine fish using the TGAI is required for dicrotophos because the active ingredient is expected to reach marine and estuarine environments because of its use in coastal regions. The preferred test species is sheepshead minnow. Results of these tests are given in Table 11.

Table 11. Acute Toxicity to Estuarine/Marine Fish

Species, Study Type	% ai	96-hour LC50 (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Sheepshead minnow *(Cyprinodon variegatus)*, Flow-through	87.65	83.8	Slightly toxic	43603306 Jones, Flynn, and Davis, 1995	Core

Since the LC_{50} falls in the range of 10 to 100 ppm, dicrotophos is slightly toxic to estuarine/marine fish on an acute basis. An unpublished report from Shell Oil Company (1965) lists the 24-hr LC_{50} for the mosquito fish (*Gambusia sp.*) as 200 ppm. No other information on this test is available. The guideline (GLN 72-3a) is fulfilled (MRID 43603306).

ii. Estuarine and Marine Fish, Chronic

An early life-stage test with an estuarine or marine fish is not required for dicrotophos because aquatic acute LC_{50} of the sheepshead minnow is greater than 1 mg/L and the EEC in water is less than 0.01 of the acute LC_{50} of the sheepshead minnow. An estuarine/marine fish life-cycle test also is not required for dicrotophos.

iii. Estuarine and Marine Invertebrates, Acute

Acute toxicity testing with estuarine/marine invertebrates using the TGAI is required for dicrotophos because the active ingredient is expected to reach marine and estuarine environments because of its use in coastal regions. The preferred test species are mysid shrimp and eastern oyster. Results of these tests are given in Table 12.

Table 12. Acute Toxicity to Estuarine/Marine Invertebrates

Species, Type of Study	% ai.	EC50 (ppm ai) 48-hr	EC50 (ppm ai) 96-hr	Toxicity Category	MRID No. Author/Year	Study Classification
Mysid *(Americamysis bahia)*	87.65	--	0.077	Very highly toxic	43603305 Jones, Flynn, and Davis, 1995	Core
Brown shrimp (*Penaeus aztecus*)	82	0.25	--	Highly toxic	Acc. No. 094598	Supplemental
Brown shrimp (*Penaeus aztecus*	80	0.12	--	Highly toxic	40228401 Mayer, 1986	Supplemental
Eastern oyster *(Crassostrea virginica)*, Flow-through shell deposition	87.65	--	>125[a]	Practically nontoxic	43739801 Cunningham and Davis, 1995	Core
Eastern oyster *(Crassostrea virginica)*, Flow-through shell deposition	82	--	>1[b]		Acc. No. 094598 Lowe, 1964	Supplemental

[a] Exposure at concentrations between 15.3 ppm and 125 ppm decreased shell growth by 12-21 %. The percent of decrease did not appear to be dependent on the exposure concentrations.

[b] Exposure at a concentration of 1 ppm decreased shell growth by 21%.

Since the EC_{50} for the mysid is less than 0.1 ppm, dicrotophos is classified as very highly toxic to estuarine/marine invertebrates on an acute basis. The oyster studies do not give a clear picture of the toxicity of dicrotophos in mature mollusks. They indicate that a significant decrease in shell growth can occur at concentrations as low as 1 ppm, but shell growth does not appear to decrease in proportion to an increase in the exposure concentrations up to 125 ppm. In this study, the EC_{50} is not an appropriate descriptor of the toxic response because the data does not reflect the dose-response model. The guidelines (GLN 72-3b and 72-3c) are fulfilled (MRIDs 43739801 and 43603305).

iv. Estuarine and Marine Invertebrate, Chronic

An estuarine/marine invertebrate life-cycle toxicity test using the TGAI is required for dicrotophos because the end-use product is expected to be transported to this environment from the intended use site, and the following conditions are met: (1) the pesticide is intended for use such that its presence in water is likely to be recurrent, (2) the mysid acute EC_{50} is less than 1 mg/L (EC_{50}=77 μg ai/L), and (3) the EEC (21.3 μg ai/L) in water is equal to or greater than 0.01 the mysid acute EC_{50} value. The preferred test species is mysid. Results of this test are given in Table 13.

Table 13. Life-Cycle Toxicity to Estuarine/Marine Invertebrates

Species, Type of Study	% ai	21-day NOEC (ppb ai)	21-day LOEC (ppb ai)	MATC[1] (ppm ai)	Most Sensitive Endpoints	MRID No. Author/Year	Study Classification
Mysid (*Americamysis bahia*), Flow-through	87.65	3.09	6.15	4.36	Male and female length, female weight	43893901 Davis and Cunningham, 1996	Core

[1] defined as the geometric mean of the NOEC and LOEC.

Based on measured concentrations, dicrotophos inhibited the growth of mysids at concentrations of 6.15 μg/L and greater. The NOEC for growth was 3.09 μg/L, reproduction of mysid was impaired at a concentration of 45.4 μg/L. The guideline (GLN 72-4) is fulfilled (MRID 43893901).

d. Toxicity to Plants

i. Terrestrial Plants

Terrestrial plant testing is not required for dicrotophos because it is not an herbicide and there is no information indicating that its use might result in phytotoxicity problems.

ii. Aquatic Plants

Aquatic plant testing is not required for dicrotophos because it is not an herbicide or fungicide and there is no information indicating that its use might result in phytotoxicity problems.

e. Fish and Wildlife Mortality Incidents

On 20 April 1983, dicrotophos poisoning caused the deaths of 30 great-tailed grackles (*Quiscalus mexicanus*) and one rock dove (*Columba livia*) in West, Texas. The U.S. Fish and Wildlife Service measured brain acetylcholinesterase activity and examined the contents of the gastrointestinal (GI) tracts in five of the dead grackles. Brain acetylcholinesterase activity was depressed 85-91% in the dead birds relative to unexposed control birds. This is indicative of poisoning by a organophosphate or carbamate pesticide. Residues of 16 and 34 ppm of dicrotophos were identified in the GI tracts of two of the birds, confirming that the poisoning was caused by dicrotophos. Sorghum seeds were found in GI tracts of four of the birds. Since dicrotophos is not registered for use on sorghum, this mortality incident is believed to be the result of either intentional poisoning or misuse of dicrotophos. (Mitchell *et al.*, 1984)

A report by the U.S. Fish and Wildlife Service attributed to dicrotophos another bird kill that occurred in Texas in March, 1982 (Incident # B0000-400-19). The species involved were the red-winged blackbirds (*Agelaius pheoniceus*), the great-tailed grackle, the brown-headed cowbird (*Molothrus ater*), the eastern meadow lark (*Sturnella magna*), and various sparrows. Birds were

found dead and dying in rice fields. Dicrotophos was identified as the causative agent by the Patuxent Wildlife Research Center, Laurel, Maryland. No further information is available on this kill.

In 1982, approximately 1100 birds of 12 species were killed by intentional poisoning in Matagorda County, Texas when someone distributed rice seeds tainted with dichrotophos or monocrotophos. The U.S. Fish and Wildlife Service determined that the rice seeds contained 210 ppm dicrotophos or 950 ppm of monocrotophos. Dead birds that were analyzed had inhibition of brain acetylcholinesterase activity (82-89%). The GI tracts of birds contained rice seeds and residues of dicrotophos (5.6-11 ppm) or monocrotophos (2.1-13 ppm). (Flickinger *et al.*, 1984).

Other incidents involving terrestrial animals are described below:

1. Catahoula Co., Louisiana. 24 May 1988 (# I000097-006)
   A farmer found a debilitated wild turkey (*Meleagris gallopavo*) in his field that had been sprayed the previous week with dicrotophos (Bidrin). The turkey was lethargic and unable to walk more than short distance. This bird had a history of following the tractor around the field during the previous week. An analysis performed by the University of Georgia at Athens, as part of the Southeastern Cooperative Wildlife Disease Study, found no residues of dicrotophos or other pesticide found in crop contents. They suspected sublethal toxicosis based on the history and the absence of gross and histopathological abnormalities.

2. Elgin, TX. 17 May 1997. (# I005361-001)
   Amvac Chemical Corporation reported that several bulls became ill after dicrotophos (Bidrin) was dumped into their water. Several of the bulls died despite being administered atropine. Chromatography identified dicrotophos in the drinking water and rumen contents. This incident appears to be the result of intentional misuse of this pesticide.

3. Texas. 1976. (# B0000-400-20)
   A Fish and Wildlife Service report lists an incident that occurred in Washington in 1976. The incident involved three species of ducks: the American wigeon (*Anas americana*), the common pintail (*Anas acuta*), and the mallard (*Anas platyrhynchos*). The ducks were found dead on two ponds that were near a livestock waste feed disposal site. Dicrotophos was identified as the causative agent by the Patuxent Wildlife Research Center, Laurel, Maryland. No further information is available on this kill.

Two fish kills have been reported that occurred after the use of dicrotophos on nearby fields. However, it is doubtful that dicrotophos was a significant causal factor in these kills because no dicrotophos residues were identified and other pesticides were also applied to the fields which are much more toxic to fish. In July 1991, 250 catfish, hundreds of bream, and many bass were killed in a pond next to a cotton field in Laurens County, Georgia (Incident # I000922-001). During the previous two weeks, λ-cyhalothrin (Karate) as well as dichrotophos (Bidrin 8) were applied to the cotton. It is likely that this kill was cause primarily by λ-cyhalothrin since it

has very high acute toxicity to fish. In July 1989, 166 fish were killed in Silver Creek and Loch Lomond in Mississippi (Incident # I000389). Nearby cotton and soybean fields had been sprayed with dichrotophos (Bidrin), malathion (Cythion), methomyl (Lannate), chlorpyrifos (Dursban), and endosulfan (Thiodan). This kill was most likely attributed to malathion, chlorpyrifos, or endosulfan, all of which have very high acute toxicity to fish.

4. Ecological Risk Assessment

a. Background

Risk characterization integrates the results of the exposure and ecotoxicity data to evaluate the likelihood of adverse ecological effects. The means of this integration is called the quotient method. For this method, risk quotients (RQs) are calculated by dividing exposure estimates by acute and chronic ecotoxicity values:

RQ = EXPOSURE/TOXICITY

RQs are then compared to OPP's levels of concern (LOCs). These LOCs are criteria used by OPP to indicate potential risk to nontarget organisms and the need to consider regulatory action. The criteria indicate that a pesticide used as directed has the potential to cause adverse effects on nontarget organisms. LOCs currently address the following risk presumption categories: (1) **acute high**--potential for acute risk is high; regulatory action may be warranted in addition to restricted use classification, (2) **acute restricted use**--the potential for acute risk is high but may be mitigated through restricted use classification, (3) **acute endangered species**--endangered species may be adversely affected; regulatory action may be warranted, and (4) **chronic risk**--the potential for chronic risk is high; regulatory action may be warranted. Currently, EFED does not perform assessments for chronic risk to plants, acute or chronic risks to nontarget insects, or chronic risk from granular/bait formulations to birds or mammals.

The ecotoxicity test values (i.e., measurement endpoints) used in the acute and chronic risk quotients are derived from required studies. Examples of ecotoxicity values derived from short-term laboratory studies that assess acute effects are: (1) LC_{50} (fish and birds), (2) LD_{50} (birds and mammals), (3) EC_{50} (aquatic plants and aquatic invertebrates), and (4) EC25 (terrestrial plants). Examples of toxicity test effect levels derived from the results of long-term laboratory studies that assess chronic effects are: (1) LOEC (birds, fish, and aquatic invertebrates), (2) NOEC (birds, fish and aquatic invertebrates), and (3) MATC (fish and aquatic invertebrates). For birds and mammals, the NOEC is generally used as the ecotoxicity test value in assessing chronic effects, although other values may be used when justified. Generally, the MATC (defined as the geometric mean of the NOEC and LOEC) is used as the ecotoxicity test value in assessing chronic effects to fish and aquatic invertebrates. However, the NOEC is used if the measurement end point is production of offspring or survival.

Risk presumptions, along with the corresponding RQs and LOCs, are given in Tables 14-16.

Table 14. Risk Presumptions for Terrestrial Animals

Risk Presumption	RQ	LOC
Acute High Risk	EEC[1]/LC50 or LD50/sqft[2] or LD50/day[3]	0.5
Acute Restricted Use	EEC/LC50 or LD50/sqft or LD50/day (or LD50 < 50 mg/kg)	0.2
Acute Endangered Species	EEC/LC50 or LD50/sqft or LD50/day	0.1
Chronic Risk	EEC/NOEC	1

[1] abbreviation for Estimated Environmental Concentration (ppm) on avian/mammalian food items
[2] (mg/ft^2) / LD50 * bodyweight
[3] (mg of toxicant consumed per day) / LD50 * bodyweight

Table 15. Risk Presumptions for Aquatic Animals

Risk Presumption	RQ	LOC
Acute High Risk	EEC[1]/LC50 or EC50	0.5
Acute Restricted Use	EEC/LC50 or EC50	0.1
Acute Endangered Species	EEC/LC50 or EC50	0.05
Chronic Risk	EEC/MATC or NOEC	1

[1] EEC = (ppm or ppb) in water

Table 16. Risk Presumptions for Plants

Risk Presumption	RQ	LOC
	Terrestrial and Semi-Aquatic Plants	
Acute High Risk	EEC[1]/EC25	1
Acute Endangered Species	EEC/EC05 or NOEC	1
	Aquatic Plants	
Acute High Risk	EEC[2]/EC50	1
Acute Endangered Species	EEC/EC05 or NOEC	1

[1] EEC = lbs ai/A
[2] EEC = (ppb/ppm) in water

b. Exposure and Risk to Nontarget Terrestrial Animals

i. Birds

The acute risk quotients for broadcast applications of emulsifiable concentrate (EC) products are given in Table 16.

Table 16. Avian Acute Risk Quotients for Single Application of Dicrotophos as an EC Product, Based on a Japanese Quail LC_{50}.

Site (application method)	Use Rate (lbs ai/A)	No. of Applications	Food Items	Maximum EEC (ppm)	LC_{50} (ppm)	Acute RQ (EEC/LC50)
Cotton	0.5	1	Short grass	120	32	3.8**
			Tall grass	55	32	1.7**
			Broadleaf plants/Insects	68	32	2.1**
			Seeds	7.5	32	0.23*
Cotton	0.5	3	Short grass	160	32	5.0**
			Tall grass	74	32	2.3**
			Broadleaf plants/Insects	92	32	2.9**
			Seeds	11	32	0.34*

** exceeds acute high, acute restricted and acute endangered species LOCs.
* exceeds acute restricted and acute endangered species LOCs.

The risk quotients for both single and multiple broadcast applications of dicrotophos exceed the avian acute high risk LOC for all wildlife food types except seeds. Therefore, terrestrial residues of dicrotophos are expected to pose a high risk of causing mortality birds. High risk is not predicted for birds that are strictly seed eaters, but they also could be at risk if they receive significant exposure through other routes. The risk quotients for all food categories exceed the LOCs for consideration of restricted use registration (0.2) and risk to threatened and endangered species (0.1).

Refined avian assessment

Because the above screen indicated a high risk to birds, a refined risk assessment was conducted for three model species: the Canada goose, the northern bobwhite quail, and the marsh wren. These species represent large herbivorous waterfowl (Anatidae), medium-sized game birds (Phasianidae), and small insectivorous songbirds (Passeriformes), respectively. The toxicity of the bobwhite was assumed to be equivalent to the California quail *(Callipepla californica*), and toxicity of the marsh wren was assumed to be equivalent to the house sparrow (*Passer domesticus*). Food consumption rates for these species were approximated based on information provided in the EPA Wildlife Exposure Handbook (EPA/600/R-93/187a). The diet for the

bobwhite was assumed to be composed of 25% insects, which is near the upper bound for adult bird, to create a high risk scenario for adult birds. Risk for bobwhite chicks, however, would be greater since their diet is nearly all insects. Estimates of maximum and average residue levels of dicrotophos on wildlife food was based on the model of Hoerger and Kenega (1972), as modified by Fletcher et al. (1994). Toxicity and exposure data were combined to estimate the number of doses equivalent to the LD_{50} that the bird is predicted to consume in a single day ("LD_{50}/day").

Table 17. Avian Acute Risk Quotients Based on LD_{50}'s of Three Surrogate Birds

No. of Applications	Model Organism	LD_{50} (mg/kg)	Diet	% BW Consumed per Day	EEC (ppm)		Acute RQ	
					Predicted Max.	Average	Predicted Max.	Average
1	Canada goose	2.28	Short grass	3.1	120	43	1.63**	0.58**
	Quail	1.89	75% seeds & pods 25% small insects	7.3	23	8.3	0.89**	0.32*
	Small passerine	3.00	Small insects	97.5	68	23	22.10**	7.48**
3	Canada goose	2.28	Short grass	3.1	160	58	2.18**	0.79**
	Quail	1.89	75% seeds & pods 25% small insects	7.3	31	11	1.21**	0.42*
	Small passerine	3.00	Small insects	97.5	92	30	29.90**	9.75**

** exceeds acute high, acute restricted and acute endangered species LOCs.
* exceeds acute restricted and acute endangered species LOCs.

Refined risk quotients for the Canada goose and a small passerine both exceed the LOC for high (0.5) risk for single and multiple applications, even if average residues are assumed. The refined RQs for quail also exceed the LOC for high risk when maximum residues are used, and is only slightly below the high risk LOC when average residues are used. All of the RQs exceed the LOCs for consideration of restricted use (0.2) and risk to threatened and endangered species (0.1). These results confirm the first tier assessment in concluding that use of dicrotophos on cotton poses a high risk of killing many different types of birds, and poses a risk to threatened and endangered birds, even with a single application. It should be noted that this refined assessment has removed many of the conservative assumptions present in the tier 1 assessment, and thus these conclusions of high risk have high certainty.

Chronic risk quotients for the use of dicrotophos on cotton are given in Table X. Chronic risk was assessed using two approaches. In the first approach, "maximum" risk quotients were calculated by dividing the bobwhite NOEC to the maximum EECs for wildlife food items. This approach is a conservative screen in which exposure is assumed to be at peak residue levels which occur immediately after the last application. For multiple applications, residues were assumed to dissipate between applications at a half-life of 2.7 days. In the second approach, "30-day mean" risk quotients were calculated by dividing the bobwhite NOEL by mean EECs for a 30-day period, beginning with the day of the first application. Residues were assumed to dissipate during this 30-day period with a half-life of 2.7 days. (For further information on maximum and 30-day EECs, see the "Terrestrial Exposure Characterization" section of this chapter). Any risks

indicated by 30-day mean risk quotients are highly certain because a 30-day exposure period is very likely long enough to produce chronic effects in birds similar to those observed in the laboratory.

Table 18. Avian Chronic Risk Quotients for Use of EC Products of Dicrotophos on Cotton, Based on a Bobwhite NOEC

UseRate (lbs ai/A)	Number of Applications	Food Items	NOEC (ppm)	EEC (ppm)		Chronic RQ (EEC/NOEC)	
				Maximum	30-Day Mean[1]	Maximum	30-Day Mean[1]
0.5	1	Short grass	0.5	120	18	240*	36*
		Tall grass	0.5	55	8.1	110*	16*
		Broadleaf plants/Insects	0.5	68	10	140*	20*
		Seeds	0.5	7.5	1.1	16*	2.2*
0.5	3	Short grass	0.5	160	53	320*	110*
		Tall Grass	0.5	74	24	150*	48*
		Broadleaf plants/Insects	0.5	92	30	180*	60*
		Tall Grass	0.5	11	3.3	22*	6.6*

* exceeds chronic LOC.
[1] Assumes first-order degredation with a half-life of 2.7 days.

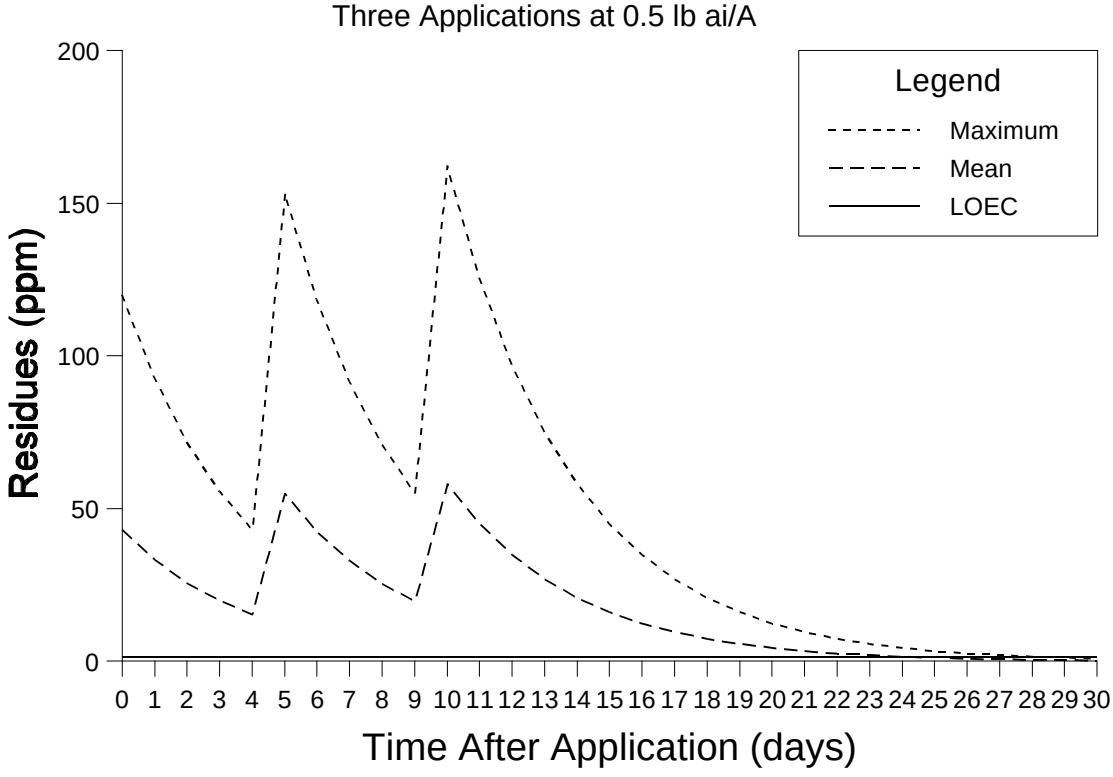
Both the maximum and the 30-day risk quotients indicate that use of dicrotophos on cotton at a rate of 0.5lb ai/A will result in high chronic risk to birds. The high risk quotient values, even when 30-day mean EECs were used, suggest that the occurrence of chronic effects in highly certain, despite the minimal persistence of dicrotophos.

To further characterize chronic risk to birds, the time-line of EECs on short grass were compared to the bobwhite LOEL (Fig. 3). Expected residues were estimated based on the model of Fletcher et al. (1994) and an assumed half-life on foliage of 2.7 days. The LOEL is the dietary concentration of 0.5 ppm, which was shown to significantly reduce egg production by bobwhites in the laboratory (MRID 44005502). Although large fluctuations in dicrotophos residues are expected, residues are expected to remain much above the LOEL at all times for at least 3 weeks. Maximum and mean residues are predicted to exceed the LOEL for 32 and 25 days, respectively. This level and duration of exposure will have a high probability of causing impairment of reproduction of birds feeding in and around treated cotton fields.

ii. Mammals

Estimating the potential for adverse effects to wild mammals is based upon EEB's draft 1995 SOP of mammalian risk assessments and methods used by Hoerger and Kenaga (1972) as modified by Fletcher *et al.* (1994). The concentration of dicrotophos in the diet that is expected to be acutely lethal to 50% of the test population (LC50) is determined by dividing the LD50 value (usually rat LD50) by the % (decimal of) body weight consumed. A risk quotient is then determined by dividing the EEC by the derived LC50 value. Risk quotients are calculated for three separate weight classes of mammals (15, 35, and 1000 g), each presumed to consume four

Fig 3. Expected Dicrotophos Residues on Short Grass



different kinds of food (grass, forage, insects, and seeds). The acute risk quotients for a single broadcast applications of dichrotophos are given in Table 19.

Table 19. Mammalian (Herbivore/Insectivore) Acute Risk Quotients for Single Application of EC Products of Dicrotophos on Cotton, Based on a rat LD50.

a. Herbivores and Insectivores.

Application Rate (lbs ai/A)	Body Weight (g)	% Body Weight Consumed	Rat LD50 (mg/kg)	EEC (ppm)			Acute RQ[1]		
				Short Grass	Broadleaved Plants & Small Insects	Large Insects	Short Grass	Broadleaved Plants & Small Insects	Large Insects
0.5	15	95	9.0	120	68	7.5	12.67	7.18	0.79
0.5	35	66	9.0	120	68	7.5	8.80	4.99	0.55
0.5	1000	15	9.0	120	68	7.5	2.00	1.13	0.13

[1] RQ = EEC / (LD50 / Proportion of Body Weight Consumed)

b. Granivores.

Application Rate (lbs ai/A)	Body Weight (g)	% Body Weight Consumed	Rat LD50 (mg/kg)	EEC (ppm) Seeds	Acute RQ[1] Seeds
0.5	15	21	9.0	7.5	0.18
0.5	35	15	9.0	7.5	0.13
0.5	1000	3	9.0	7.5	0.03

[1] RQ = EEC / (LD50 / Proportion of Body Weight Consumed)

For a single application, acute risk quotients range from 0.13 to 13 for herbivorous and insectivorous mammals, and 0.025 to 0.18 for gramivorous mammals. Risk quotients exceed the high acute risk LOC (0.5) for most herbivorous and insectivorous mammals (all except larger mammals that feed on larger insects). Risk quotients for gramnivorous mammals do not exceed the high risk LOC, but do exceed the endangered species LOC (0.1) for small and medium mammals.

The acute risk quotients for multiple broadcast applications of dichrotophos are given in Table 20.

Table 20. Mammalian (Herbivore/Insectivore) Acute Risk Quotients for Multiple Applications of EC Products of Dicrotophos on Cotton, Based on a rat LD50 and Peak EECs.

a. Herbivores and Insectivores.

Appl. Rate (lbs ai/A)/ # Appl.	Body Weight (g)	% Body Weight Consumed	Rat LD50 (mg/kg)	Peak EEC (ppm)			Acute RQ[1]		
				Short Grass	Broadleaved Plants & Small Insects	Large Insects	Short Grass	Broadleaved Plants & Small Insects	Large Insects
0.5/3	15	95	9.0	160	92	11	16.89	9.71	1.16
0.5/3	35	66	9.0	160	92	11	11.73	6.75	0.81
0.5/3	1000	15	9.0	160	92	11	2.67	1.53	0.18

[1] RQ = EEC / (LD50 / Proportion of Body Weight Consumed)

b. Granivores.

Appl. Rate (lbs ai/A)/ # Appl	Body Weight (g)	% Body Weight Consumed	Rat LD50 (mg/kg)	Peak EEC (ppm) Seeds	Acute RQ[1] Seeds
0.5/3	15	21	9.0	11	0.26
0.5/3	35	15	9.0	11	0.18
0.5/3	1000	3	9.0	11	0.04

[1] RQ = EEC / (LD50 / Proportion of Body Weight Consumed)

For three applications, acute risk quotients range from 0.18 to 17 for herbivorous and insectivorous mammals, and 0.037 to 0.18 for granivorous mammals. Risk quotients exceed the high acute risk LOC (0.5) for most herbivorous and insectivorous mammals (all except larger mammals that feed on larger insects). Risk quotients for granivorous mammals do not exceed the high risk LOC, but do exceed restricted use LOC (0.2) for small mammals, and the endangered species LOC (0.1) for small and medium mammals.

Chronic risk quotients for mammals are presented in table 21. These risk quotients are based on the NOAEL of 2.0 ppm that was established in a 3-generational rat reproduction study. While a short-term exposure to the peak concentration possibly could cause chronic effects,

exposure over a longer duration would have a greater certainty of causing these effects. Therefore, chronic risk to mammals was also assessed based on average EEC's for a 30-day period, beginning with the day of the first application, as well as on peak EEC's.

Table 21. Mammalian Chronic Risk Quotients for Use of EC Products of Dicrotophos on Cotton, Based on a Rat NOAEL

Use rate (lbs ai/A)	Number of Applications	Food Items	NOAEL (ppm)	EEC (ppm)		Chronic RQ (EEC/NOAEL)	
				Maximum	30-Day Mean[1]	Maximum	30-Day Mean[1]
0.5	1	Short grass	2	120	18	60*	9.0*
		Tall grass	2	55	8.1	28*	4.1*
		Broadleaf plants/Insects	2	68	10	34*	5.0*
		Seeds	2	7.5	1.1	3.8*	0.55*
0.5	3	Short grass	2	160	53	80*	27*
		Tall Grass	2	74	24	37*	12*
		Broadleaf plants/Insects	2	92	30	46*	15*
		Tall Grass	2	11	3.3	5.5*	1.7*

* exceeds chronic LOC.
[1] Assumes first-order degredation with a half-life of 2.7 days.

Both the maximum and the 30-day risk quotients indicate that use of dicrotophos on cotton at a rate of 0.5 lb ai/A will result in high chronic risk to mammals. The risk quotient values were high even when 30-day mean EECs were used, suggesting that the occurrence of chronic effects in mammals is highly certain.

iii. Insects

Currently, EFED does not conduct quantitative risk assessments for nontarget insects . However, acute toxicity testing show that dicrotophos is highly toxic to honeybees (LD_{50}=0.076 μg/bee, MRID 05001991). Dicrotophos residues on foliage have been found to remain toxic to bees and other beneficial insects for 2 to 16 days. Therefore, use of dicrotophos on cotton is expected to pose a high risk to honeybees and other nontarget insects, especially when it is applied to flowering cotton plants.

c. Exposure and Risk to Nontarget Aquatic Animals

i. Fish

As a conservative screen, risk quotients were calculated based on three aerial applications at the maximum use rate (0.5 lb ai/A) with a 5-day interval between applications. Acute quotients are given in Table 22.

Table 22. Risk Quotients for Acute Effects on Fish from Use of Dicrotophos on Cotton.

Habitat Type	Test Species	LC50 (ppb)	Peak EEC (ppb)	Acute RQ (EEC/LC50)
Freshwater	Rainbow trout	6300	21.3	<0.01
Marine and estuarine	Sheepshead minnow	83,800	21.3	<0.01

The acute risk quotient is less than the acute high risk, restricted use, and endangered species levels of concern for freshwater and saltwater fish. Therefore, the Agency concludes that this use poses minimal risk to all fish, including endangered species. Chronic risk has not been assessed because data on the chronic toxicity of dicrotophos to fish is not available.

ii. Aquatic Invertebrates

Acute quotients are given in Table 23.

Table 23. Risk Quotients for Acute Effects on Aquatic Invertebrates from Use of Dicrotophos on Cotton.

Habitat Type	Test Species	LC50 (ppb)	Peak EEC[1] (ppb)	Acute RQ (EEC/LC50)
Freshwater	Waterflea	12.7	21.3	1.68
Marine and estuarine	Mysid	77	21.3	0.28

[1]Based on three applications at the maximum application rate of 0.5 lb ai/A.

For freshwater species, the risk quotient for use of dicrotophos on cotton at the maximum application rate exceeds the levels of concern for acute high risk, restricted use, and endangered species. Therefore, the Agency concludes that this use poses a high acute risk to freshwater invertebrates. For marine and estuarine invertebrates, the risk quotient is less than the level of concern for high risk (0.5), but exceeds the level of concern for restricted use and endangered species. Therefore, the Agency concludes that this use does not pose a high risk to marine and estuarine species, but does pose enough risk that effects on threatened and endangeres species is a concern.

The chronic risk quotient is given in Table 24.

Table 24. Risk Quotients for Chronic Effects on Aquatic Invertebrates from Use of Dicrotophos on Cotton.

Habitat type	Test Species	MATC (ppb)	21-Day Average EEC[1] (ppb)	Chronic RQ (EEC/MATC)
Marine and estuarine	Mysid	4.36	8.51	1.95

[1]Based on three applications at the maximum application rate of 0.5 lb ai/A.

For marine and estuarine species, the risk quotient for use of dicrotophos on cotton at the maximum application rate exceeds the level of concern for high chronic risk. Therefore, the Agency concludes that this use poses a high chronic risk to marine and freshwater invertebrates. No chronic data are available for freshwater invertebrates. However, the Agency concludes that chronic risk to freshwater species is also high because acute toxicity indicates that freshwater invertebrates are more sensitive to dicrotophos than are marine and estuarine invertebrates.

d. Exposure and Risk to Nontarget Plants

A risk assessment was not conducted for nontarget plants because dicrotophos is an insecticide and there is no indication that it is phytotoxic. Risk to nontarget plants is assumed to be minimal.

5. Endangered Species

Use of dicrotophos on cotton poses a risk to threatened and endangered species of birds, mammals, reptiles, amphibians (terrestrial forms), and aquatic invertebrates (freshwater and saltwater). Risk from the tree-injection use of dicrotophos is probably small for most species, but there is a potential that the fruit and nuts of treated trees could contain residues that would be harmful to birds and mammals. Therefore, this use should be considered a risk to threatened and endangered species of birds and mammals that feed extensively on fruit and/or nuts.

The Agency has developed a program (the "Endangered Species Protection Program") to identify pesticides whose use may cause adverse impacts on endangered and threatened species, and to implement mitigation measures that will eliminate the adverse impacts. At present, the program is being implemented on an interim basis as described in a Federal Register Notice (54 FR 27984-28008, July 3, 1989), and is providing information to pesticide users to help them protect these species on a voluntary basis. As currently planned, the final program will call for label modifications referring to required limitations on pesticide uses, typically as depicted in county-specific bulletins or by other site-specific mechanisms as specified by state partners. A final program, which may be altered from the interim program, will be described in a future Federal Register Notice. The Agency is not imposing label modifications at this time through the RED. Rather, any requirements for product use modifications will occur in the future under the Endangered Species Protection Program.

6. Risk Characterization

TERRESTRIAL RISK ASSESSMENT

Dicrotophos is a a contact, systemic organophosphate (OP) insecticide and aracnicide used on cotton and on ornamentals and/or shade trees. The use of dicrotophos on cotton has a high risk of killing birds and other terrestrial wildlife. This risk is predicted by our risk assessment, and has been confirmed by two terrestrial field studies and wildlife poisoning reports. Use on cotton is also expected to pose a high risk of chronic effects on birds and mammals, including impairment of reproduction. In contrast, the tree-injection use on ornamentals and shade trees is expected to pose minimal risk to terrestrial organisms.

The major routes of dissipation of dicrotophos in the environment are microbial-mediated degradation in soil and movement into surface and shallow ground waters. Laboratory studies show that dicrotophos degrades rapidly in a sandy loam soil under aerobic ($t_{1/2}$ = 2.7 days) and

anaerobic (t1/2 = 7 days) conditions. CO_2 accounts for 58% of the applied after 14 days posttreatment under aerobic conditions and 18% of the applied under anaerobic conditions. The major soil degradate, SD 6167, degrades rapidly under aerobic conditions, but is more persistent under anaerobic conditions (48% after 33 days). The registrant has been asked to provide additional information concerning the persistence of this degradate under anaerobic conditions. Laboratory studies also show that dicrotophos is stable to photolysis on soil surfaces (sandy loam soil - pH 5.7).

Although the registrant submitted four terrestrial field dissipation studies, none of these are acceptable. Only one of the studies conducted in Mississippi can be upgraded if the registrant provides additional data concerning the formation and decline of dicrotophos degradates.

Like other OP pesticides, dicrotophos exhibits high acute toxicity due to irreversible inhibition of cholinesterase enzymes. Significant inhibition of brain and blood cholinesterases have been observed in rats administered dicrotophos at doses as small as 0.5 mg ai/kg (MRID 43759801). As with humans, exposure of wildlife to cholinesterase inhibiting pesticides disrupts normal neuromuscular control. Death can occur rapidly, due primarily to respiratory failure. Organophosphate exposure can also result in chronic effects in animals such as reproduction impairment and delayed neuropathy. Dicrotophos, however, has relatively low toxicity to aquatic organisms compared to most insecticides. The primary risk from the use of dicrotophos is acute and chronic effects in terrestrial vertebrates. Effects to terrestrial invertebrates has not been well-characterized.

An extensive amount of data are available on the acute toxicity of dicrotophos to birds. These data clearly show that dicrotophos exhibits high acute toxicity to a wide variety of birds, including upland game birds, ducks, passarines (songbirds), and doves. All of the acute oral tests that have been performed with dicrotophos place its toxicity in the “very highly toxic” range (LD_{50}<10 mg/kg). Acute toxicity for the rat is also in the “very highly toxic” range. Chronic effects occur at levels below those that are acutely toxic. Reproductive impairment has been observed in both birds and mammals at dietary concentrations betwe en 1.5 and 5 ppm.

The acute risk assessment for birds was based on a dietary LC_{50} of 32 ppm for the Japanese Quail. A supplemental study conducted in 1967 yielded a lower dietary LC_{50} value (13 ppm), but was considered unreliable because the test protocol used was not adequately described. Although the accuracy of this early study is uncertain, it suggests that the bobwhite may be more sensitive than the Japanese quail, and that the acute risk to birds may be even greater than predicted by the risk assessment.

Even with a relatively low application rate of 0.5 lb ai/A, use of dicrotophos on cotton poses a high risk to birds and mammals. Risk quotients based on a screening-level risk assessment were 0.23-3.8 for a single application and 0.34-5.0 for three applications. These risk quotients exceeded the level of concern (LOC) for all food types except seeds. A more refined risk assessment was conducted for three model species: the Canada goose, the northern bobwhite quail, and the marsh wren. These species represent large herbivorous waterfowl (Anatidae),

medium-sized game birds (Phasianidae), and small insectivorous songbirds (Passeriformes), respectively. The results for the marsh wren indicated that dicrotophos use poses a very certain risk of killing small insectivorous songbirds. These birds are predicted to receive a dose 7-10 times greater than the LD_{50}, the dose predicted to kill 50% of the exposed population, even when average residues are assumed. Songbirds are prevalent in cotton fields during the summer (see below). The results for the Canada goose and the bobwhite quail indicate a risk that is less but still moderately high. For the Canada goose, the risk quotients exceeded 1 when based on maximum residues, and were less than 1 but still greater than the LOC (0.5) when based on average residues. For the bobwhite, the risk quotients were near or slightly greater than 1 (depending on the number of applications) when based on maximum residues, and slightly less than the LOC of 0.5 when based on average residues.

The refined assessment described above is **not** believed to be conservative, i.e., erring on the side of calling a risk even when one does not exists. In fact, field data indicate that the opposite might be true. The analysis yielded a risk quotient of only 0.42 for the bobwhite quail when dicrotophos was applied three times at 0.5 lb ai/A per application and exposure to average residue levels were assumed. This risk quotient is less than the LOC for high risk (0.5). However, a terrestrial field study conducted in Arizona provides strong evidence that three applications of dicrotophos at 0.2 lb/A per application (40% of the maximum rate) resulted in mortality of Gambel's quail. The mortality of one quail was confirmed by detection of dicrotophos residues on the skin and in the tissue. There are several reasons why the risk assessment may underestimate risk. Compared to animals in the laboratory, animals in the wild might be more susceptible because they are exposed to multiple stressors in addition to the chemical (e.g. extreme environmental conditions, predation pressure, and disease). Furthermore, animals in the wild are likely to be exposed to pesticides through routes other than in the diet (e.g., via drinking water, dermal absorption, and inhalation). Therefore, there appears to be a risk of mortality to all birds that feed in cotton fields treated with dicrotophos, although the risk is most certain for songbirds.

Monocrotophos is a highly toxic metabolite that can be formed by demethylation of dicrotophos. Monocrotophos has been included in the tolerance assessment for dicrotophos. Monocrotophos was used as an insecticide in the United States until its registration was canceled in 1988. Numerous incidents of bird mortality incidents have been attributed to monocrotophos, both in the U.S. and abroad. In 1994, use of monocrotophos in Argentina to control grasshoppers caused huge die-offs of wintering Swainson's hawks that fed on the contaminated insects. Scientists from the U.S. Forest Service estimated that 20,000 Swainson's hawks were killed in a single season. Laboratory studies on the degradation of dicrotophos do not indicate that monocrotophos forms in soil or water in any significant quantities. Metabolism studies with the laying hen (MRID 44031201) and domestic goats (MRID 43962401) indicates that monocrotophos is not formed in significant amounts in the metabolism of dicrotophos by animals. However, monocrotophos may be a significant metabolite in plants. A metabolism in cotton study found a significant proportion of applied residues to be in the form of monocrotophos. At the time of harvest, monocrotophos represented 10.0% and 7.83% of total residues in cotton seeds and cotton stems, respectively. However, this information is not reliable, as residues were not

measured until 30 days after the last application, when only trace amounts of residues remained. The amount of monocrotophos that forms in or on foliage soon after application is currently not known (Memorandum, April 2, 1997).

Birds are known to make use of cotton fields for food and cover. Field studies conducted in cotton fields in Alabama (MRID 40917001) and Arizona (MRID 40873701) both concluded that birds were "diverse and had high species richness and abundance" in the test fields. Passarines (songbirds) were the most common type of bird using cotton fields in both studies. Quail and doves were also fairly common in cotton fields in Arizona. Bird use of cotton fields was higher in Arizona than in Alabama. More birds are likely attracted to cotton fields in the Southwest because the irrigated fields provide dense vegetative cover that is scarce elsewhere in the desert environment. In addition, cotton fields in the Southwest frequently occur along rivers, and the associated riparian habitats that are favored by birds. Additional information on the use of cotton field by birds is provided by Gusey and Maturgo (1973). Data for Georgia indicate that there is medium to high use of cotton by songbirds for feeding during the summer months. In addition, data for Georgia, South Carolina, and Texas indicate medium to high use of cotton by quail for feeding, nesting, and brood rearing.

Overall, songbirds and quail are likely to be the most frequently exposed birds in cotton treated with dicrotophos. The risk assessment indicate that many songbirds are highly vulnerable to acute poisoning by dicrotophos due to their small size and insectivorous feeding habit. The risk assessment indicate that adult quail are somewhat less vulnerable but still at risk of acute poisoning. The vulnerability of young quail, which are mostly insectivorous, is likely to be similar to that of songbirds. The field studies confirm that use of dicrotophos on cotton can cause mortality of both quail and songbirds.

One field study was conducted in cotton fields in southwestern Arizona. Three aerial applications were made at the rate of 0.2 lb ai/A, which is 60% less than the maximum label rate of 0.5 lb ai/A. Fifty-six incidents of mortality or behavioral signs of toxicity (hereafter referred to as "casualties") were observed. In a classification on likelihood of being caused by dicrotophos poisoning, 5 were "definite", 8 were "possible", 22 were "not related", and 18 were "unknown" (i.e.,not enough information to determine causation). Therefore, the number of observed casualties attributable to dicrotophos use was between 5 and 31. Due to inherent inefficiencies in carcass searching, there were probably many more mortalities that were not observed. The Gambel's quail was the most frequently observed species suffering casualties, with 13 casualties known or suspected to be treatment related. Mortality was also observed in Gambel's quail that were fitted with radio collars. The death of one radio-collared quail was confirmed as being treatment related with detection of dicrotophos residues in tissue and on skin and feathers. One mortality was suspected of being treatment related (dicrotophos residues found on skin and feathers but not in tissue), and three others could possibly have been treatment related. Another species that was affected was the horn lark, of which 3 were found dead.

A second field study that was conducted in Alabama also found significant mortality. In this study, three applications of dicrotophos were made at 0.5 lb ai/A each. Out of 35 observed

casualties, 5 were “definite”, 5 were “possible”, 18 were “not related”, and 7 were “unknown”. Thus, the number of observed casualties that were attributed to dicrotophos use was between 5 and 17. The casualties that were considered definitely treatment related were four indigo buntings and an American crow. Again, due to inherent inefficiencies in carcass searching, there were probably many more mortalities that were not observed. These two studies together show that the registered use of dicrotophos on cotton frequently causes mortality of birds, especially songbirds and quail, as well as possibly other terrestrial wildlife.

In addition to the high acute risk, dicrotophos poses a high risk of causing impairment of avian reproduction. Risk quotients for chronic effects on birds, based on 30-day time-averaged residues, were 2.2 to 36 for a single application, and 6.6 to 110 for three applications. Laboratory data show that the egg production of the Northern bobwhite is reduced at dietary concentrations as low as 1.5 ppm. Peak environmental concentrations on wildlife food items are predicted to be as high as 120 ppm. With three applications, residues of dicrotophos are expected to remain above the LOAEL for several weeks (see Fig. 1). With this level and duration of exposure, the probability of impairment of reproduction of birds feeding in and around treated cotton fields is very high. In addition, exposure to dicrotophos can decrease the survival of young birds after they are hatched. Stromborg *et al*. (1988) found that young European starlings (*Sturnus vulgaris*) in nest boxes that were orally exposed to dicrotophos had significantly greater mortality than unexposed birds. Impaired reproduction and increased mortality of young and old birds will work together to adversely affect population of birds around treated cotton fields.

Acute toxicity testing show that dicrotophos is highly toxic to honey bees. Dicrotophos residues on foliage have been found to remain toxic to bees and other beneficial insects for 2 to 16 days. Therefore, use of dicrotophos on cotton is expected to pose a high risk to honeybees and other nontarget insects, especially when it is applied to flowering cotton plants.

AQUATIC RISK CHARACTERIZATION

In laboratory hydrolysis studies, dicrotophos is stable at acidic and neutral pH’s. The extrapolated half-lives are 117 days and 72 days. At alkaline pH (9), dicrotophos degrades more rapidly with a half-life of 28 days. The major hydrolytic degradates are SD 6167 and SD 228001 which are present at 31.2% and 16.5% after 28 days in alkaline solutions. The persistence of these degradates is not known. Dicrotophos is also stable to photolysis in aqueous solutions (pH 7).

Dicrotophos has a low binding affinity to soil (Kads = 0.07-3.58 ml/g) and is likely to be found in the water column. Adsorption/desorption studies show that dicrotophos is mobile in sand, sandy loam, silt loam and clay soils with Koc values of 11-187. Because dicrotophos does not hyrolyze readily under acidic and neutral conditions and is mobile, the Agency is requesting aerobic aquatic metabolism data.

Use of dicrotophos as a tree-injection chemical is not expected to pose a problem to water

resources. Use of dicrotophos on cotton, however, could pose an acute surface water problem. Surface water models (GENEEC and PRZM-EXAMS) indicate that dicrotophos may reach surface waters at a peak concentration of 37-21 ug/L, but levels do not appear to accumulate. Ground water modeling using the SCI-GROW II model show that dicrotophos is not expected to pose a significant ground water problem (0.0048 ppb). Although environmental fate data and modeling indicate that dicrotophos can pose an acute surface water problem, the STORET monitoring database did not show any dicrotophos detections for either surface or ground water sites.

Dicrotophos applied to cotton is likely to reach freshwater habitats and estuarine habitats along the southern Atlantic Coast and the Gulf Coast. This exposure is not predicted to harm fish. Risk quotients indicate a high risk of acute effects to freshwater invertebrates, but not to marine or estuarine invertebrates. Risk quotients indicate high risk of chronic effects to marine and estuarine invertebrates. Although the Agency has no data on the chronic effects of dicrotophos to freshwater invertebrates, high chronic risk is assumed since high acute risk is predicted. Although some of the risk quotients for aquatic invertebrates indicate high risk, the risk to aquatic environments does not appear to be particularly greatrelative to other insecticides.

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Appendix I
Data Table

Date:
Case No:
Chemical No:

PHASE IV
DATA REQUIREMENTS FOR
ECOLOGICAL EFFECTS BRANCH

Data Requirements	Composition[1]	Use Pattern[2]	Does EPA Have Data To Satisfy This Requirement? (Yes, No)	Bibliographic Citation	Must Additional Data Be Submitted under FIFRA3(c)(2)(B)?
6 Basic Studies in Bold					
71-1(a) Acute Avian Oral, Quail/Duck		1	Y	MRID 00160000	No
71-1(b) Acute Avian Oral, Quail/Duck	(TEP)				
71-2(a) Acute Avian Diet, Quail		1	Y	MRID 00022923	No
71-2(b) Acute Avian Diet, Duck		1	Y	MRID 00022923	No
71-3 Wild Mammal Toxicity					
71-4(a) Avian Reproduction Quail		1	Y	MRID 44005502	No
71-4(b) Avian Reproduction Duck		1	Y	MRID 44005501	No
71-5(a) Simulated Terrestrial Field Study					
71-5(b) Actual Terrestrial Field Study		1	No	MRID 40873701 & MRID 40917001	No
72-1(a) Acute Fish Toxicity Bluegill		1	Y	MRID 40098001	No
72-1(b) Acute Fish Toxicity Bluegill	(TEP)				
72-1(c) Acute Fish Toxicity Rainbow Trout		1	Y	MRID 40098001	No
72-1(d) Acute Fish Toxicity Rainbow Trout	(TEP)				
72-2(a) Acute Aquatic Invertebrate Toxicity		1	Y	MRID 43787901 & MRID 40098001	No
72-2(b) Acute Aquatic Invertebrate Toxicity	(TEP)				
72-3(a) Acute Estu/Mari Tox Fish		1	Y	MRID 43603306	No
72-3(b) Acute Estu/Mari Tox Mollusk		1	Y	MRID 43739801	No
72-3(c) Acute Estu.Mari Tox Shrimp		1	Y	MRID 43603305	No

* In Bibliographic Citation column indicates study may be upgradeable

Date:
Case No:
Chemical No:

PHASE IV
DATA REQUIREMENTS FOR
ECOLOGICAL EFFECTS BRANCH

Data Requirements	Composition[1]	Use Pattern[2]	Does EPA Have Data To Satisfy This Requirement? (Yes, No)	Bibliographic Citation	Must Additional Data Be Submitted under FIFRA3(c)(2)(B)?
72-3(d) Acute Estu/Mari Tox Fish	(TEP)				
72-3(e) Acute Estu/Mari Tox Mollusk	(TEP)				
72-3(f) Acute Estu/Mari Tox Shrimp	(TEP)				
72-4(a) Early Life-Stage Fish		1	No		No[1]
72-4(b) Live-Cycle Aquatic Invertebrate		1	No		Yes[2]
72-5 Life-Cycle Fish		1	No		Reserved
72-6 Aquatic Org. Accumulation					
72-7(a) Simulated Aquatic Field Study					
72-7(b) Actual Aquatic Field Study					
122-1(a) Seed Germ./Seedling Emerg.		1	No		No
122-1(b) Vegetative Vigor		1	No		No
122-2 Aquatic Plant Growth		1	No		No
123-1(a) Seed Germ./Seedling Emerg.		1	No		No
123-1(b) Vegetative Vigor		1	No		No
123-2 Aquatic Plant Growth		1	No		No
124-1 Terrestrial Field Study					
124-2 Aquatic Field Study					

[1] A early life-stage toxicity test is not required because the acute LC_{50}'s for freshwater and marine/estuarine fish are greater than 1 mg/L and the risk quotients for freshwater and marine/estuarine fish are less than 0.01.

[2] A life-cycle toxicity test with a freshwater invertebrate is required because the acute EC_{50} of the waterflea is less than 1 mg/L and the acute risk quotients for the mysid is greater than 1. The test species should be *Daphnia magna*. The requirement for a life-cycle toxicity test with an marine/estuarine invertebrate has been fulfilled by a study with the mysid, MRID 43893901.

* In Bibliographic Citation column indicates study may be upgradeable

Date:
Case No:
Chemical No:

PHASE IV
DATA REQUIREMENTS FOR
ECOLOGICAL EFFECTS BRANCH

Data Requirements	Composition[1]	Use Pattern[2]	Does EPA Have Data To Satisfy This Requirement? (Yes, No)	Bibliographic Citation	Must Additional Data Be Submitted under FIFRA3(c)(2)(B)?
141-1 Honey Bee Acute Contact		1	Y	MRID 05001991	No
141-2 Honey Bee Residue on Foliage		1	Y	MRID 05000837 & MRID 05009353	No
141-5 Field Test for Pollinators					

* In Bibliographic Citation column indicates study may be upgradeable

[1]Composition: TGAI=Technical grade of the active ingredient; PAIRA=Pure active ingredient, radiolabeled; TEP=Typical end-use product

[2]Use Patterns: 1=Terrestrial/Food; 2=Terrestrial/Feed; 3=Terrestrial Non-Food; 4=Aquatic Food; 5=Aquatic Non-Food (Outdoor); 6=Aquatic Non-Food (Industrial); 7=Aquatic Non-Food (Residential); 8=Greenhouse Food; 9=Greenhouse Non-Food; 10=Forestry; 11=Residential Outdoor; 12=Indoor Food; 13=Indoor Non-Food; 14=Indoor Medical; 15=Indoor Residential